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FEB 11 1948

VOLUME 3, NUMBER 2 FEBRUARY, 1948

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FORMERLY MONTHLY TECHNICAL SECTION OF NATIONAL PETROLEUM NEWS

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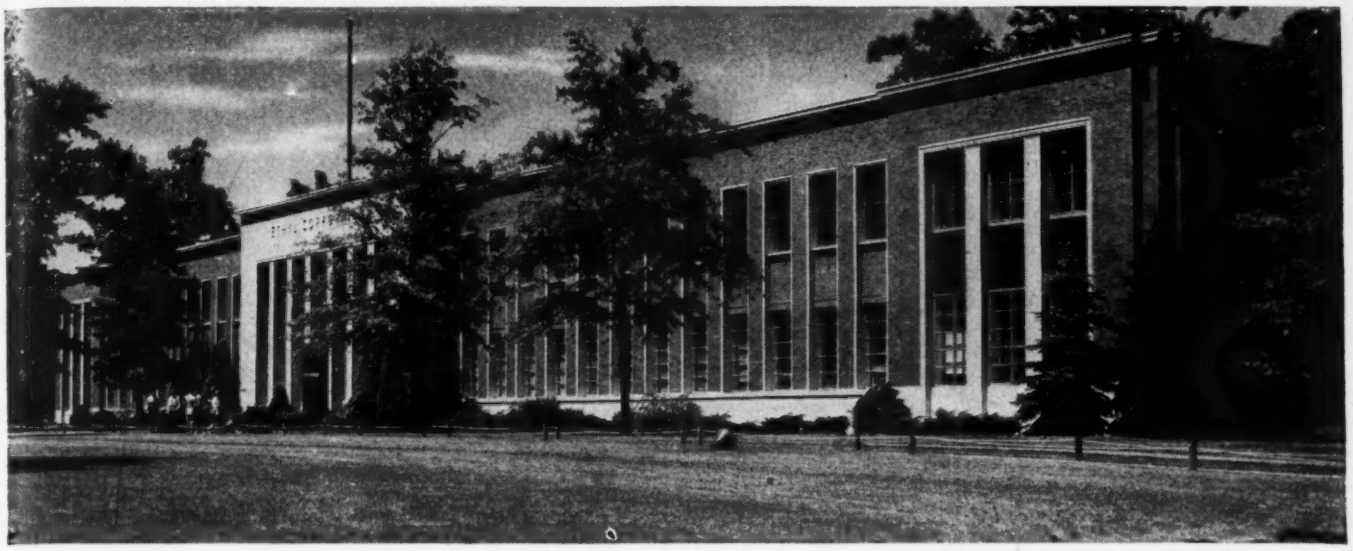

When in Detroit, visit the Ethyl Laboratories

They are designed to serve the oil and automotive industries

For over twenty years the Ethyl Laboratories have performed an indispensable function in the organized research of the automotive and oil industries, which continuously brings better and more economical automotive transportation to the American people.

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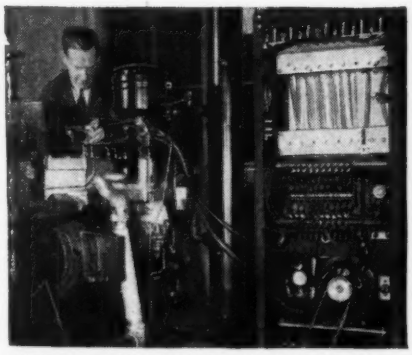
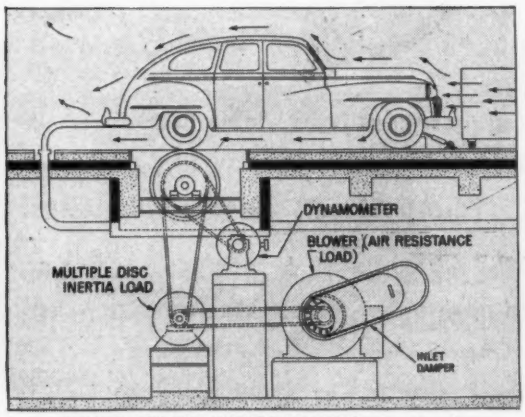
Ethyl Corporation cordially invites technologists of oil, automotive and related companies to inspect the Ethyl Research Laboratories and to discuss problems of mutual interest. The laboratories are just twenty-five minutes from downtown Detroit.

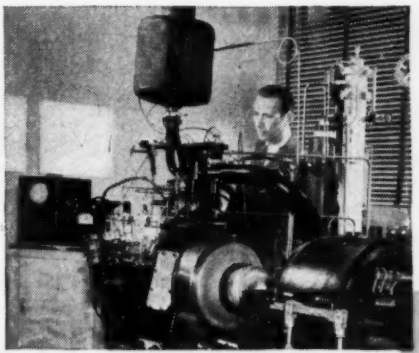
THREE EXAMPLES OF SPECIAL EQUIPMENT IN THE ETHYL LABORATORIES



THIS PLASTIC HIGHWAY enables Ethyl engineers to "bring the road into the laboratory." A combination engine and dynamometer control makes it possible to duplicate on the dynamometer stand the sequence of engine speed and loading recorded during any actual trip on the highway. The control equipment utilizes a plastic tape and operates on the principle of the player piano.



INDOOR "ROAD" KNOCK RATINGS may now be obtained on the rolls of this chassis dynamometer provided with special automatic control equipment developed by Ethyl Laboratories. Speed-time relationships for accelerations run on these rolls duplicate those obtained on the road. Knock ratings made on the rolls are essentially the same as those made on the road, and their reproducibility is better.



SPECIAL SINGLE-CYLINDER ENGINE studies indicate fuel antiknock performance under conditions including wide ranges of speed, manifold pressure and compression ratio. The extreme flexibility of this special engine makes it possible for Ethyl research workers to rate experimental fuels under conditions which appear likely to exist within the cylinders of engines of the future.

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VOLUME 3
NUMBER 2
FEBRUARY, 1948
PUBLISHED
MONTHLY

PETROLEUM PROCESSING

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OILGRAM NEWS
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PLATT'S OIL PRICE HANDBOOK

Covering the Management, Design, Operation, Equipment, Products of Plants Processing Crude Oil and Natural Gas into Fuels, Lubricants, Chemicals

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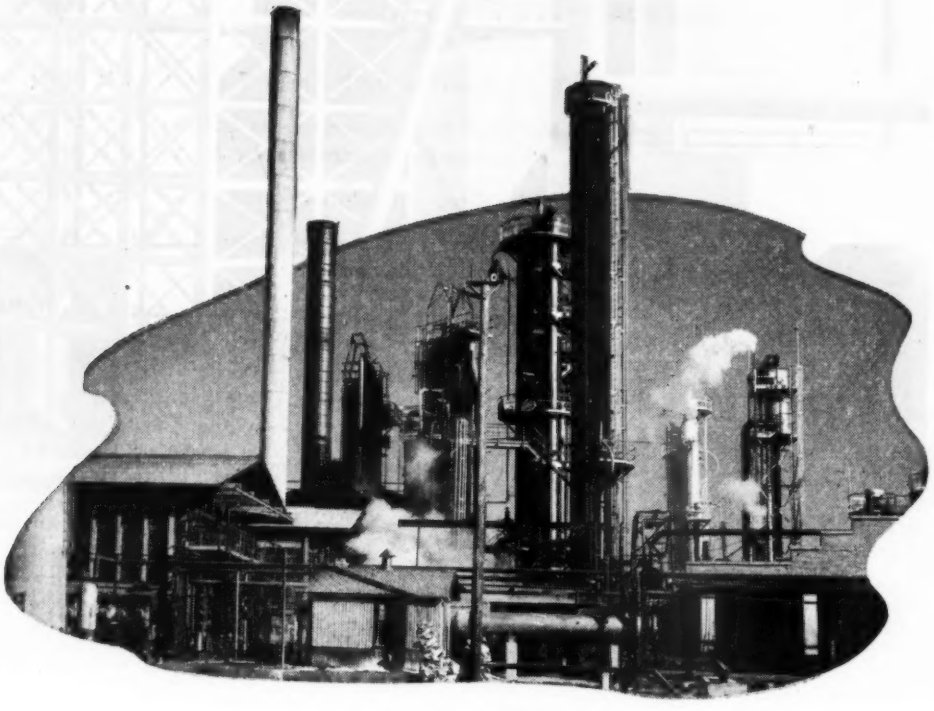
What makes a Smaller Refinery



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The size of a refinery measured in barrels per day capacity is one thing. Its competitive ability . . . its flexibility of product and adaptability to changing market requirements is another. The latter makes the difference between just refining and big business.

Taking advantage of Universal's facilities . . . of Universal research, engineering, processes and service . . . many refineries of moderate capacity have become big business operations. These refineries, UOP licensees, have found big business to be good business.

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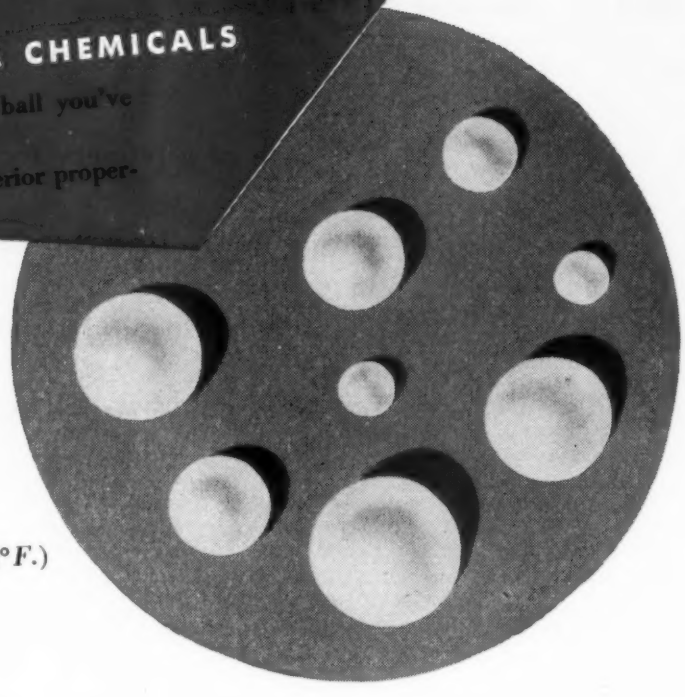

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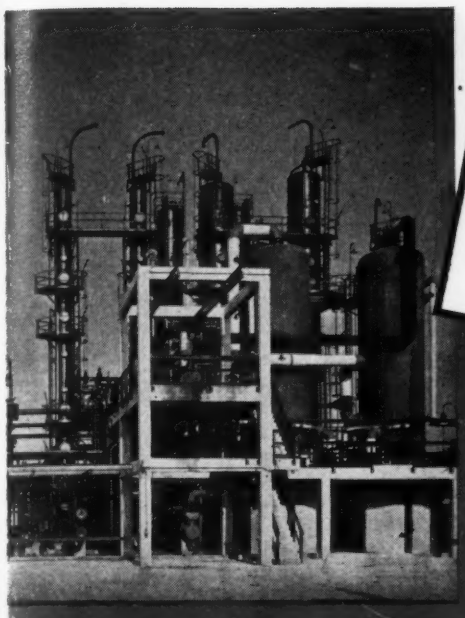

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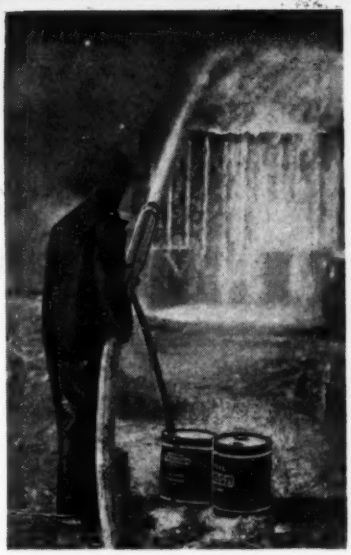
NOW, when pumps, tanks, pipe and other equipment take so long to replace, it is doubly important to have adequate Aer-O-Foam protection wherever fire damage would cause production "bottle-necks".



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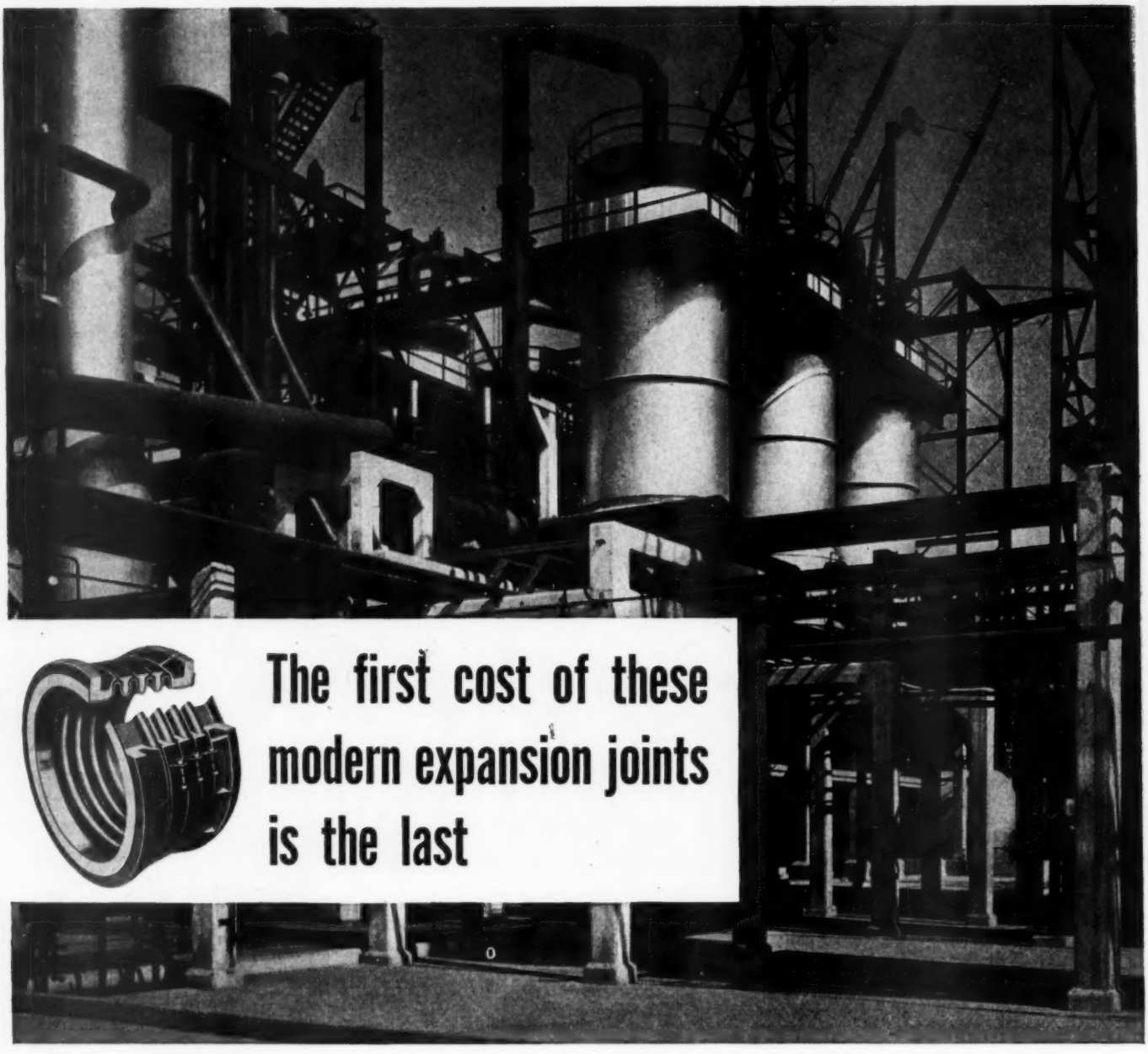

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Badger Packless Expansion Joints for the Petroleum Industry are compact and easy to install. They require no more space than a flanged fitting. Being made of stainless steel and other alloys, they resist the corrosive effects of the products and processing chemicals handled in oil refineries and other petroleum processing plants.

Furthermore, Badger Joints are scientifically heat-treated during the process of manufacture to remove forming stresses. This heat-treatment assures greater resistance to flexing stresses and longer service life.

For complete data on these improved expansion joints, write for Bulletin No. 100.

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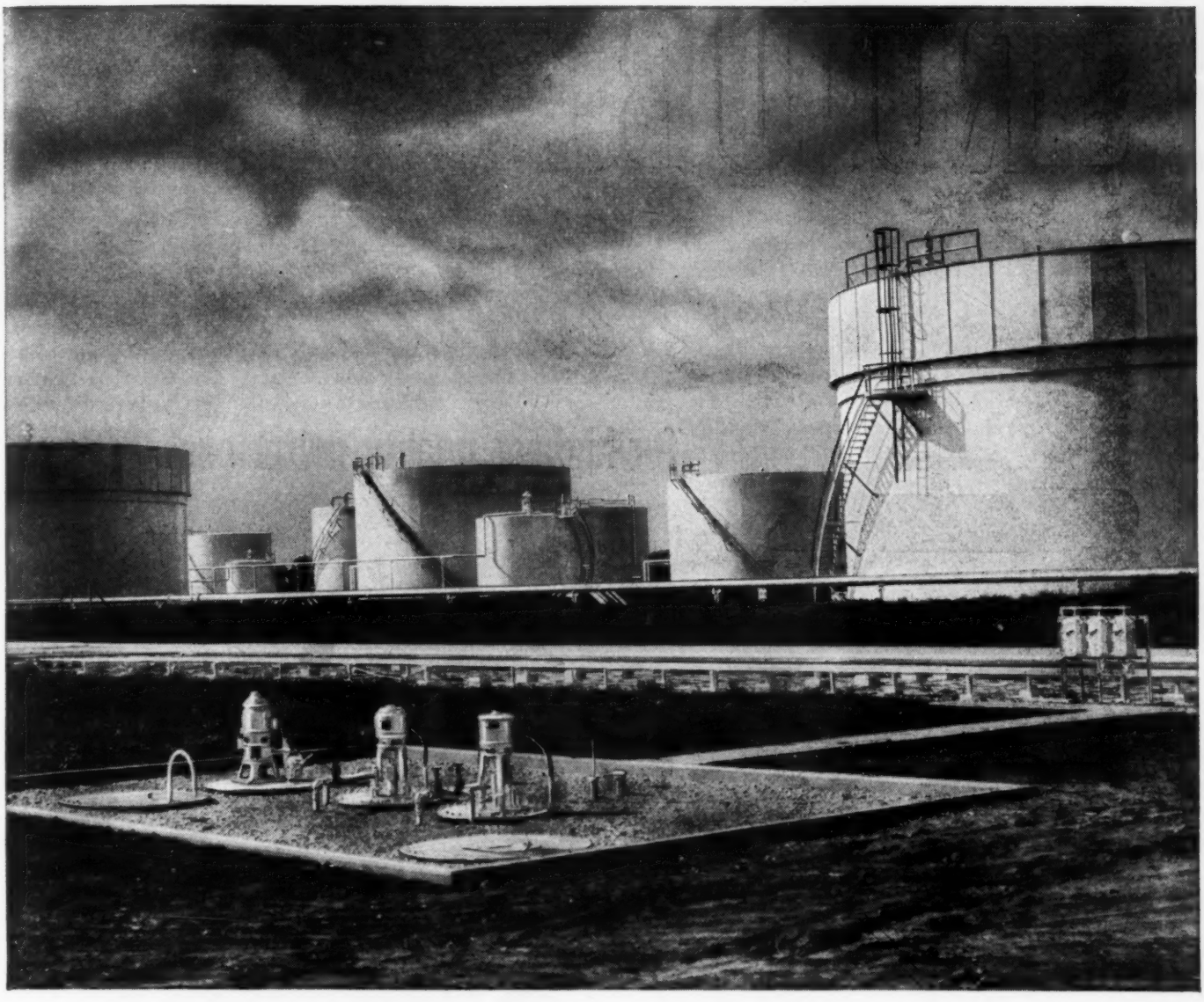

WHERE OUTPUT EQUALS INPUT

Sounds fundamental . . . but where conservation is not practiced properly, there is a costly difference between what is pumped into a terminal and what is pumped out. Vapor losses make this difference. The two Expansion Roof tanks (left and right) are proof that conservation is complete in this terminal . . . that breathing losses have been eliminated and when vapor volumes are balanced during filling and emptying operations (as they normally are) there are no filling losses.

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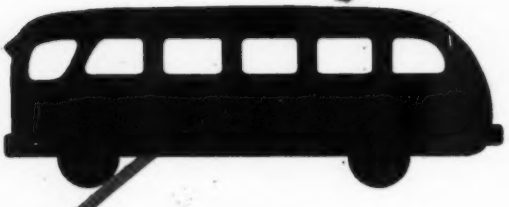

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What's Happening!

February 1
1948

Summary of Current News Developments Concerning Oil Men

Synthetic Fuels Were Prominent in the news at many points last month. In his budget message to Congress Jan. 12, President Truman recommended extension of the Bureau of Mines' synthetic liquid fuels program, noting that while new oil pool discoveries are being made each year, "reserves are becoming inadequate to match our rapidly growing requirements." Fortunately, however, he added, "we have large supplies of coal and oil shale and moderate supplies of natural gas, which can be converted into liquid fuel."

Defense Secretary Forrestal a week later warned that "foreseeable" oil production in continental U. S. would be 2 million b/d short of meeting military and domestic civilian needs for a major war effort, and also urged tremendous expansion of our efforts on synthetic fuels. He estimated that a synthetic fuels program costing $8 billion would be necessary to overcome such a 2 million b/d deficiency in crude supplies.

Forrestal urged that the federal government should "not only support pilot plant operations in synthetic liquid fuel industry but also should support a few large-scale plants sufficient to provide the engineering know-how and to advance technical developments." He went on to explain that he hoped a synthetic fuels industry could be developed under the "aegis of private industry" but pointed out that there might be some fields in which federal government could help.

Government Subsidy to get nation started immediately on a "widespread" program for the commercial production of synthetic fuels is favored by Rep. Short (R., Mo.), chairman of the House Armed Services Oil Subcommittee. His committee is currently conducting an investigation of the military oil supply situation, which is scheduled to get into the synthetic situation Feb. 23, with later meetings on the 25th and 26th.

Following a closed session at which top military officers testified on the armed forces' need for oil products, Short told a reporter that "we'd better get busy right now on a widespread program." "Government and industry together should do the job," he said, adding that he thought there would be need for government financial help to get the program rolling.

Extension of Bureau's Program for study of synthetic fuels will be strongly supported by both military and administration forces. Present program, in operation since middle of 1944, is due to end June 30, 1949. Bills now before Congress would extend it three years and appropriate an additional $30,000,000.

Bureau now has only one demonstration plant in operation, producing 50 to 100 b/d of products from oil shale at Rifle, Colo. If program is extended, Bureau wants to build a 50 to 80 b/d demonstration plant operating on Fischer-Tropsch basic process, and larger one for coal hydrogenation.

Construction of Commercial Plants financed by private capital is moving ahead. Latest development along that line is announcement that construction on Stanolind's synthetic plant in Hugoton field will begin about the end of February. Announcement came indirectly, through Kansas Gov. Frank Carlson, who also said he understood plant would not be completed until January, 1950.

Stanolind officials have never announced the estimated construction cost, but the governor stated that "speculation as to the ultimate cost of the plant runs as high as $80,000,000." The plant, operating on natural gas, is expected to produce 7000 to 8000 gal. of liquid fuels daily from 100 million cu. ft. of gas, as well as 100 millions lbs. of chemicals annually.

• • •

Higher Compression Ratio Cars are definitely going to be with us next fall, according to R. J. S. Pigott, chief engineer of Gulf Research and Development Co., and new SAE president. At least two major popular automobiles will be on the market by then with 7.75 to 1 engines, he revealed at a press conference held during the SAE meeting in Detroit last month.

Previous reports have stated that G. M.'s Cadillac and Oldsmobile lines were shortly going to higher compression engines, but Pigott's remarks are the first definite word on the subject.

Gasoline of 88 Research Octane will be required to operate the new cars properly, he further stated. This fact should relieve many refiners who were worrying about how to supply the 92-93 research octane fuel which rumors prevalent a few months ago had said would be needed.

Some gasolines now on the market are already up to 88 research octane, Pigott claims, with the majority of premium fuels only a few points below that level.

• • •

Settlement Was Reached Jan. 18 in the 296-day old strike at Pure Oil Co.'s Toledo refinery. Contract, effective until Dec. 31, 1948, calls for total of 30c per hour increase in pay over scale paid at time plant was struck in March of 1947. Another clause calls for holidays falling on Sunday to be observed the following Monday, thus calling for overtime holiday pay on that day.

Nine million bbls. of crude processing time has been lost at the plant since the strike began, it is es-

timated. Near-zero temperatures in Great Lakes area are hampering efforts to get refinery back on stream, and although some equipment is expected to be in operation early this month, full production is not seen possible before the middle of March.

Strike at Texas City Refinery of Pan-American Refining Corp., called Jan. 1, was ended after ten days when OWIU accepted offer of 12c per hour net increase. Previous demand was for a 28c increase. Settlement calls for a 25c increase in the basic rate and a 9c per hour cost of living bonus to replace the present 22c bonus, thus making the net boost 12c per hour. Plant is rated at 93,000 b/d.

No National Wage Pattern for the settlement of future demands in the refining industry has been set by acceptance of the 12c increase at Pan-Am, however, OWIU President Knight says. "Conditions warrant substantially more than the boys settled for at Pan American," he said, cataloging the Texas City settlement as a "purely local situation."

Earlier, when the Texas City strike was still in progress, Knight had said it did not necessarily represent the general demands OWIU will make on a national basis. Union policy committee, meeting shortly, will decide what they are to be.

Loss of 1,303,000 Bbls. of crude processing time has been occasioned by strikes during the first three weeks of this year, based on rated capacity of the refineries struck—Pan-Am at Texas City, and Pure at Toledo. Total loss during 1947 due to strikes was 20,406,000 bbls., a survey by National Petroleum News showed.

• • •

Record Crude Runs to Stills were chalked up last month, with the week ending Jan. 3 setting a record all-time high of 5,637,000 b/d. To achieve that figure, refineries operated at 99.4% of rated capacity. A year ago crude runs to still were only 4,854,000 b/d.

During the following week, however, the one ending Jan. 10, operations fell sharply to 93.2% of capacity, or 5,289,000 b/d. One factor in the decline was a brief strike at Pan-American's Texas City 93,000 b/d refinery. Some recovery was shown during the next week, ending Jan. 17, with runs at 5,344,000 b/d, 94.2% capacity.

Crude Production also climbed to new records, with top of 5,326,137 b/d for week ending Jan. 17. Some excitement was displayed over a new West Texas well which the discoverer described as the biggest strike since East Texas. The well is reported to have flowed 880 b/d on ⅜-in. tubing choke with a gas-oil ratio of 4000 to 1. Depth is 12,022 ft.

Gasoline Shortages This Summer and continued tight fuel oil supplies next winter are forecast by Max Ball, director of Interior Department's Oil and Gas Division. Tanker shortages have eased off, he stated, but industry still is critically short of steel for expansion of production, refining and transportation facilities.

• • •

No Federal Oil Rationing is needed now, however, in the opinion of Senator Wherry (R., Nebr.), chairman of the Senate Small Business Oil Subcommittee which has been investigating petroleum product shortages for the past several months. Early in the month he declared that the oil industry "on the whole is doing a pretty good job" in getting supplies to consumers, and there is no need for compulsory government allocation or rationing control this winter.

Increased Freight Rates for petroleum and petroleum products in tank cars were authorized recently by the Interstate Commerce Commission. With the lone exception of lubricating oil, all tank car shipments of petroleum and petroleum products are subject to a 20% rate increase up to a maximum of 9c per 100 lbs. Lube oil shipments are subject to the full 20% boost.

• • •

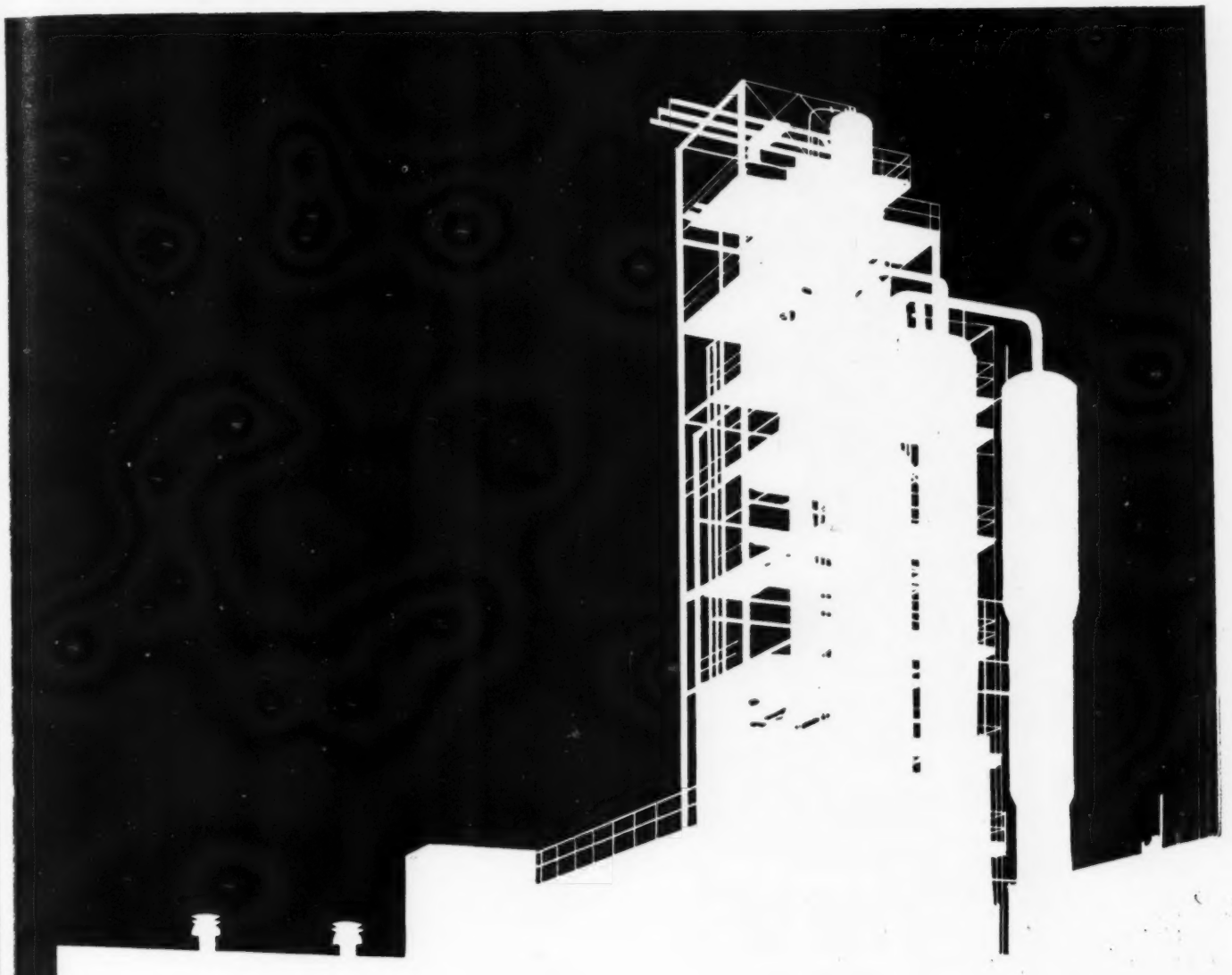
Citcon Corp.'s New Lube Plant at Lake Charles, La., got under way last month with the breaking of ground for construction. Plant, to cost $30,000,000, is owned jointly by Cities Service Co. and Continental Oil Co.

Indiana Standard's Second Fluid catalytic cracking unit at Whiting is now scheduled to go on stream either next month or in April. The unit, of 25,000 b/d charge capacity, was originally planned for completion the latter part of 1947.

Five Companies Are Building a natural gasoline plant capable of ultimately processing 85 million cu. ft. of gas daily. Construction has been started near Maysville, Okla. An output of 300,000 gals. daily of natural gasoline, butane and propane is expected. Plant will be owned jointly by Cities Service Oil Co., Carter Oil Co., Sinclair Prairie Oil Co., J. E. Crosbie, Inc., and Warren Petroleum Corp., with Warren to be the operator.

Continental Oil Co. completed the purchase of the 100-octane gasoline plant at Ponca City, Okla., erected during the war by DPC at a cost of $16,452,000. Purchase price was $3,125,000 and company plans to spend about $1,000,000 more for alterations, including switching the 20,000 b/d TCC catalytic cracker from countercurrent to concurrent reactor operation.

Stanolind Gas and Oil Co. will start construction soon of a natural gasoline plant in the Hugoton Field, Kans. Located near Ulysses, Kans., the plant is designed to process 100,000,000 cu. ft. of gas daily, with a peak capacity of 150,000,000 cu. ft. Yields of 26,000 gals. per day of natural gasoline and 36,000 gals. per day of butane and propane are expected.



centrifugal compression pares cracking costs

Catalytic cracking units require huge volumes of air. That means a big compression job—and explains the preference of many modern refineries for Carrier centrifugal air compressors. One of the largest oil companies, which installed its first Carrier centrifugal air compressor in 1942, has re-ordered four times for catalytic cracking units—a total of 12 units and strong testimony to Carrier efficiency.

The reason is plain—Carrier is the world's foremost builder of large multi-stage centrifugal compressors. And, with recent greatly expanded manufacturing facilities, Carrier's production is now increased to insure prompt deliveries.

Carrier compressors are backed by more than 25 years of design, development and operating experience. A highly qualified staff of technically trained men specializes in manufacturing, application and servicing of this fine equipment. This adds up to high-efficiency, precision-built, trouble-free compressors.

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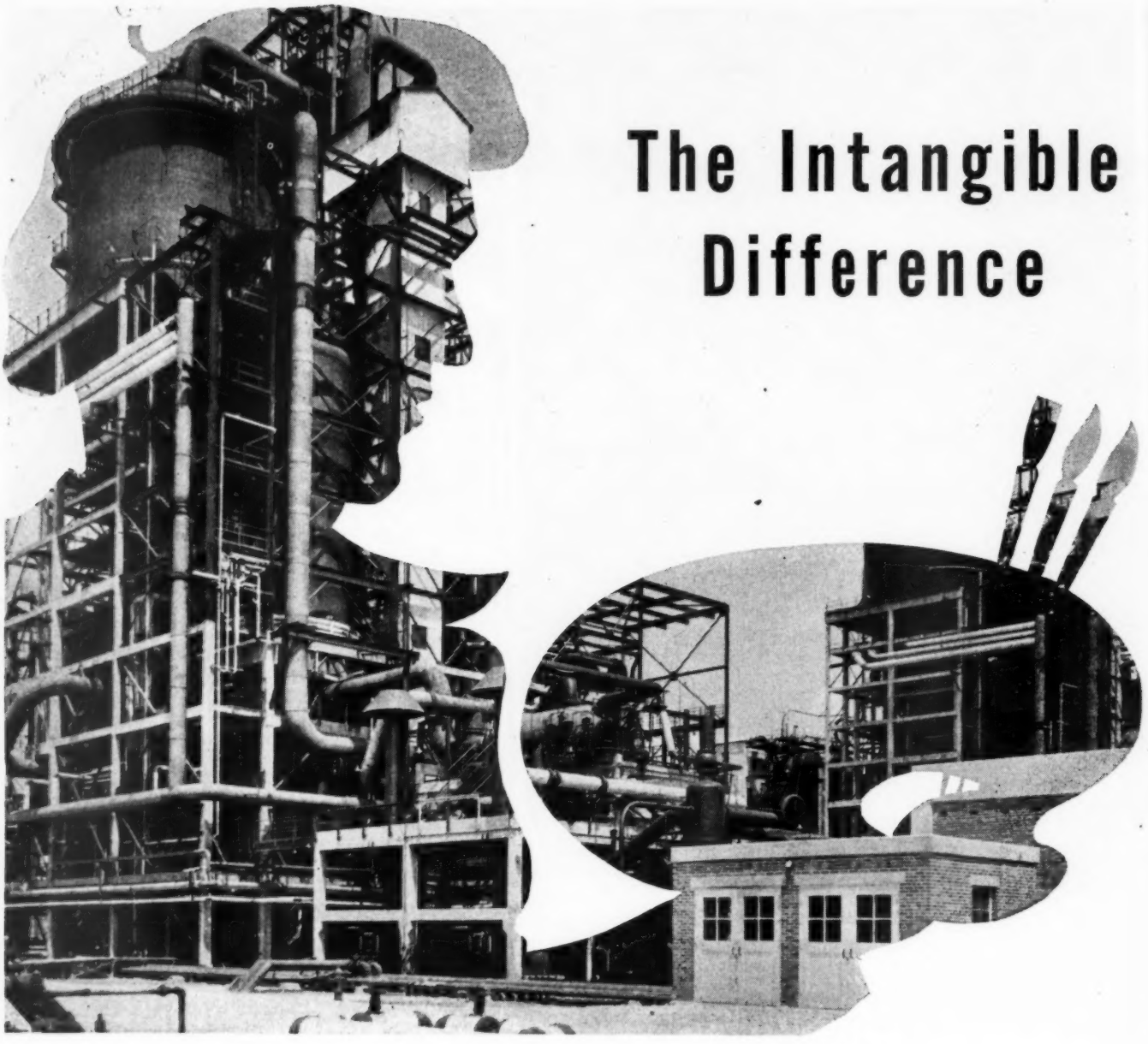

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Even though the same art schools and the same materials are available to all, only a few artists ever paint masterpieces.

It's this intangible difference in human endeavor—more commonly called "know how"—that has accounted for every major advance in petroleum processing. It is also the one factor that holds the greatest hope for progress in the future.

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TOMORROW

... IN PETROLEUM TECHNOLOGY

Current technological and economic developments discussed here in the light of their future bearing on petroleum refining operations include:

- **Aviation fuels not being neglected in peacetime.**
- **Petroleum synthesis plans proceeding at accelerated pace.**
- **Brand buying seen as best performance guarantee.**
- **Schoch acetylene process to receive commercial application.**
- **Petro-chemical production showed increase in 1946.**

Aviation Fuels Not Being Neglected

IT IS ENCOURAGING to note, from a national defense viewpoint, that aviation gasoline and jet fuels are not being ignored by the petroleum industry simply because demands have dropped so sharply from their wartime peak. Instead, it is apparent that the research and planning efforts of the Armed Forces are proceeding hand in hand with petroleum industry endeavors and that the industry is striving earnestly to see that a wartime emergency could be met.

Problems, however, are plentiful. Military authorities have decreed a minimum specification of 10% of aromatics in grade 100/130 aviation gasoline, and hope that the grade 115/145 aviation gasoline can be raised to the same standard by mid-year. In setting this standard, the services realized that it would further tighten the supply situation, but the mechanical factors involved outweighed this consideration.

As regards civilian aeronautics, recent recommendations of the National Fire Protective Association are of particular pertinence in view of the recent grounding of DC-6 airliners. Among these recommendations are several suggestions of interest to the petroleum industry: (1) use of direct fuel injection in order to eliminate carburetors, which permit backfiring, (2) use of nonflammable lubricating oils, and (3) use of solid or high-flash fuels, to minimize fire hazards. In regard to these suggestions, *Business Week*(1) comments that fuel injection "has been used in Europe for years; here, too, on a small scale. Nonflammable oils and high-flash fuels are being developed but with small prospects of early success."

Many petroleum companies are busily engaged in research on jet fuels. All in all, it would appear that research efforts are proceeding at a reasonable pace and that the petroleum industry is making a real effort, shortages or not, to meet current military demands. Whether these could be satisfied in the event of another war, however, is a real question.

(1) Anon., *Business Week*, No. 956,28,31 (1947), "Cause of DC-6 Fires Found."

Petroleum Synthesis Plans Proceeding at Faster Rate

FIVE YEARS AGO, only a few scientists, engineers, executives, and economists dared to suggest that petroleum substitutes — synthetic fuels and shale oil derivatives— might become economic before the end of this decade. Inured by years of low prices for crude oil, the petroleum industry looked upon petroleum substitutes as insurance for future generations or tools for nationalistic economic self-sufficiency, and only the major companies and refinery construction organizations devoted research efforts to this field, along with awakening attention from government agencies interested for varying reasons.

Today, however, the high price levels attained by crude oils, combined with the prospect that these prices will go even higher and abetted by research developments of the past few years, all have produced a remarkable unanimity among forecasters as to the immediate future for petroleum substitutes, especially those produced by the Synthine process.

Karl J. Nelson of the Standard Oil Development Co., recently told the Chemical Market Research Assn. that 25% of the nation's natural gas reserves—the equivalent of 3,000,000,000 barrels of synthetic gasoline—ought to be readily available for Synthine synthesis, the other 75% being unusable for reasons of other demands, scattered locations, etc. According to Nelson, a survey last spring indicated that this quantity of gasoline could be made available at filling stations for 25 cents or less per gallon, taxes included; regular-grade gasoline was selling at that time for 22 cents per gallon.

Moreover, Nelson indicated that 300,000,000,000 barrels of synthetic gasoline from coal (via the Synthine process) could be made available at a service station price of 26-31 cents per gallon. Actual synthesis from natural gas was said to be two cents per gallon cheaper than production from crude oil, but plant investments were said to be about three times higher.

P. C. Keith recently told the Petroleum Engineers' Club of Dallas that ten synthesis plants, producing the equivalent of 400,000 barrels of oil per day, may very likely be built in the next ten years. He pointed out, incidentally, that the conversion of coal to gasoline would put a ceiling on any tendency of natural gas prices to run away because of large demands for petroleum synthesis. Moreover, he stated that these ten plants could produce 5,000,000 pounds daily of chemical derivatives—nearly 70% of present national production—and that the relatively inflexible market for chemical products thereby rendered chemical synthesis of only incidental importance since plant economics could not safely take profits from these into consideration.

W. C. Schroeder, chief of the Bureau of Mines' Office of Synthetic Liquid Fuels, strongly urges the immediate beginning of a synthetic fuels industry construction program to provide 1,000,000-2,000,000 b/d of fuels. Such a program, he states, would require eight or nine billion dollars and perhaps 15,000,000 tons of steel besides making heavy demands on manpower supplies and supplies of other materials. This program would be from five to ten times the magnitude of the wartime synthetic rubber program, and Schroeder declares that "it would be most desirable to avoid such a drain of national resources during an emergency."

Brand Buying Seen as Best Performance Guarantee

SPACE DOES NOT permit discussion of the technical details of R. J. S. Pigott's recent API paper entitled "Buy on Performance and Depend on Brands," but it does seem worthwhile to comment here on the apparent lack of faith which a reputable mechanical engineer has in the tests and specifications which have been laboriously and painstakingly devised by the petroleum and allied industries.

What Pigott is presumably trying to put across is something far removed from "advertising"—the fact that the development of products of high quality cannot be guaranteed by mere conformance to physical or chemical specifications, that uniform

high quality can only be attained by actual use tests whose conduct and interpretation requires much "know how" and diligent study.

It is not to be expected that all refiners and users will agree unreservedly that the latter should exclusively use only those brands of products which are known to have been developed after elaborate research programs — that would put half of the industry out of business. Instead, this paper should be a challenge to scientists and technologists to develop tests whose correlation with use can be interpreted accurately and a spur to refiners to make certain that their marketing programs include proper attention to the guarantee of uniform high quality. The quibbler might ask, "How can a brand become established if users are only buying existing brands" "How can the user tell which of several elaborately-developed brands is best"? "What are refiners who have not developed an integrated line of brands going to do with those fractions not included in their name products"? "What about the small refiner who can't afford a multi-million-dollar research program"?

These are valid questions, but it must be pointed out that petroleum refining is a most complex art, and there is no question that the "big-boys" have an edge through their elaborate research programs. Each specific advantage is quickly dissipated by the general advances in knowledge, however, and the small refiners—through licensing, careful attention to developments, and the maximum amount of "research" possible—certainly do not need to fear that they will be *per se* eliminated by any sudden mass buying by brands. From the consumer's viewpoint, however, Pigott's remarks are of undeniable pertinence.

Schoch Acetylene Process To Be Used Commercially

AFTER 18 YEARS of study by Dr. Eugene Paul Schoch and his associates at the University of Texas, it is said the Schoch electric arc process for the synthesis of acetylene from natural gas will be employed this spring in a plant at Houston of the Houston Oxygen Co. Capacity of the plant is expected to be 24,000,000 cu. ft. of acetylene per year, and manufacturing costs are estimated at 4-4.5c per lb., less than the cost of producing acetylene from calcium carbide (the standard process) and only about 80% of the cost of producing acetylene by the German electric arc process, although plant investments for both arc processes are about the same

The process involves passing natural gas at 300° F. and atmospheric pressure between rotating electrodes, the electrical discharge producing an exit gas containing (by volume) 10% acetylene, 40% hydrogen, and 50% (unreacted) methane, along with some by-product carbon black (about 1.5 lb. per 1000 cu. ft. of natural gas) which is filtered out. Following an oil wash for removal of certain hydrocarbons, the acetylene is dissolved in a solvent (from which it may be obtained as a 99% pure product); the methane and hydrogen at present are used for fuel.

Carbon black yields could be increased to 10.5 lb. per 1000 cu. ft. of natural gas if desired, by converting the acetylene. The by-product carbon black has a slight coating of organic matter which can be removed; tests are in process to determine the properties of the cleaned product.

It is said[2] that some $300,000 have been put into this research so far, and research and pilot plant efforts will now "be directed toward the use of the technique to produce other chemicals."

"Plant investment for the new process, based on 1946 costs, is estimated at about $113 to $123 per kw. power rating"; what this amounts to on a per pound basis is not clear, although the pilot plant had a maximum natural gas charge rate of 1500 cu. ft. per hr. and a maximum power rate of 75 kw.

Acetylene is a hydrocarbon of considerable industrial and chemical significance, and any process that will lower its cost is of more than passing interest.

Petro-Chemical Production Showed Increase in 1946

STATISTICS are curious tools. When available, they are carefully scanned to confirm or deny trends, or to establish new ones. As regards petroleum chemicals production, for example, vastly increasing attention would seem to guarantee that these figures would increase from year to year, and such has been the case. What the statistics do not show as such, however, is that this steady gain has been continued first in the face of wartime building material shortages and now in spite of diminution of demand for certain wartime-needed petroleum chemicals.

According to a recent report[3] of the U. S. Tariff Commission, production of petroleum chemical crude products totaled 3.5 billion pounds in 1946, compared with 3.3 billion pounds in 1945, 2.8 billion pounds in 1944, and 1.5 billion pounds in 1943. "The increase was due to a larger output of aliphatic hydrocarbons, chiefly butadiene for use in synthetic rubber, and propane and propylene for the manufacture of isopropyl alcohol and other chemicals.

"Production of aromatics and naphthenes from petroleum decreased sharply in 1946, compared with the preceding year," reflecting "chiefly the decreased production of toluene and xylene for military purposes."

Total production of aromatics and naphthenes from petroleum amounted to 599,572,000 pounds, including 28,897,000 pounds of naphthenic acids, 67,443,000 pounds of toluene (production from coal tar amounted to 189,000,000 pounds), 263,125,000 pounds of xylenes (coal-tar xylene production totaled only 59,000,000 pounds), and 240,107,000 pounds of "other aromatics," including cresylic acids.

As regards aliphatic hydrocarbons, total 1946 production amounted to 2,917,155,000 pounds, divided as follows: ethylene, 294,605,000 pounds; propane and propylene, 208,620,000 pounds; butadiene (including the small quantity produced from alcohol), 1,074,040,000 pounds; 1-butene and 2-butene fraction, 632,056,000 pounds; "all other" C_4 hydrocarbons, 480,710,000 pounds; C_5 hydrocarbons, 42,273,000 pounds; and "all other aliphatic hydrocarbons," 184,851,000 pounds.

Some 36,598,000 pounds of petroleum sulphonates were produced in 1946 for use as surface-active agents, and a large fraction of the 45,868,000 pounds of "sulfonated benzenoid compounds" produced was composed of petroleum-based alkyl aryl sulfonates. Other petroleum chemicals were employed in the synthesis of numerous other surface-active agents.

Among other production statistics were those for the following chemicals, derived in large part from petroleum: acetaldehyde, 351,916,000 pounds; acetic acid (synthetic), 285,000,000 pounds; acetic anhydride, 521,911,000 pounds; acetone from isopropyl alcohol, 298,148,000 pounds; amyl acetates, 10,564,000 pounds; amyl alcohols, 15,475,000 pounds; butyl alcohols, 230,537,000 pounds; ethylene glycol, 192,176,000 pounds; formaldehyde (37% by weight), 458,877,000 pounds; carbon tetrachloride, 148,674,000 pounds; chloroparaffins, 14,766,000 pounds; methyl chloride, 28,498,000 pounds; isopropyl alcohol (90%), 542,997,000 pounds; and methanol (synthetic), 509,820,000 pounds.

"Notwithstanding shortages of raw materials, the output of plastic materials in 1946 continued its upward trend of the past several years. Production totaled 994,000,000 pounds, 22% greater than in 1945."

(2) Anon., *Business Week*, No. 953, 78, 80 (1947), "Lab Process Goes Commercial."

(3) Anon., *Synthetic Organic Chemicals, United States Production and Sales*, 1946, Preliminary, United States Tariff Commission, Washington, 1947.

This new seating arrangement

PUTS WEAR IN THE PROPER PLACE

Newly-designed Jenkins gate valve uses hard, corrosion-resistant wrought Monel seat rings to assure tightness . . . at oil pressure up to 400 psi.

JENKINS BROS. . . . well-known valve makers . . . have taken another big step ahead with their newly-designed 270-U valve, shown at right.

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The wedge is high-quality bronze—strong enough to last through many openings and closures, yet inexpensive and easy to replace.

And for the seat rings—where the constant heavy wear comes—Jenkins Bros. use Monel*. Work hardened to 190 Brinell (2½ times harder than the wedge), the rings will hardly ever have to be replaced. And since they are made of *wrought* Monel, Jenkins is able to hold the price of this new valve in the moderate range.

In tests, these seat rings stood up under thousands of openings and closings . . . *without a sign of wear.*

These Monel seats fight corrosion, too . . . another reason why Jenkins especially recommends their 270-U valve for severe conditions, such as those encountered in refineries, dye houses, and chemical, food, and rubber plants. Moreover, the Monel seats are galvanically neutral to the bronze wedge and body metal—even in salt or polluted water.

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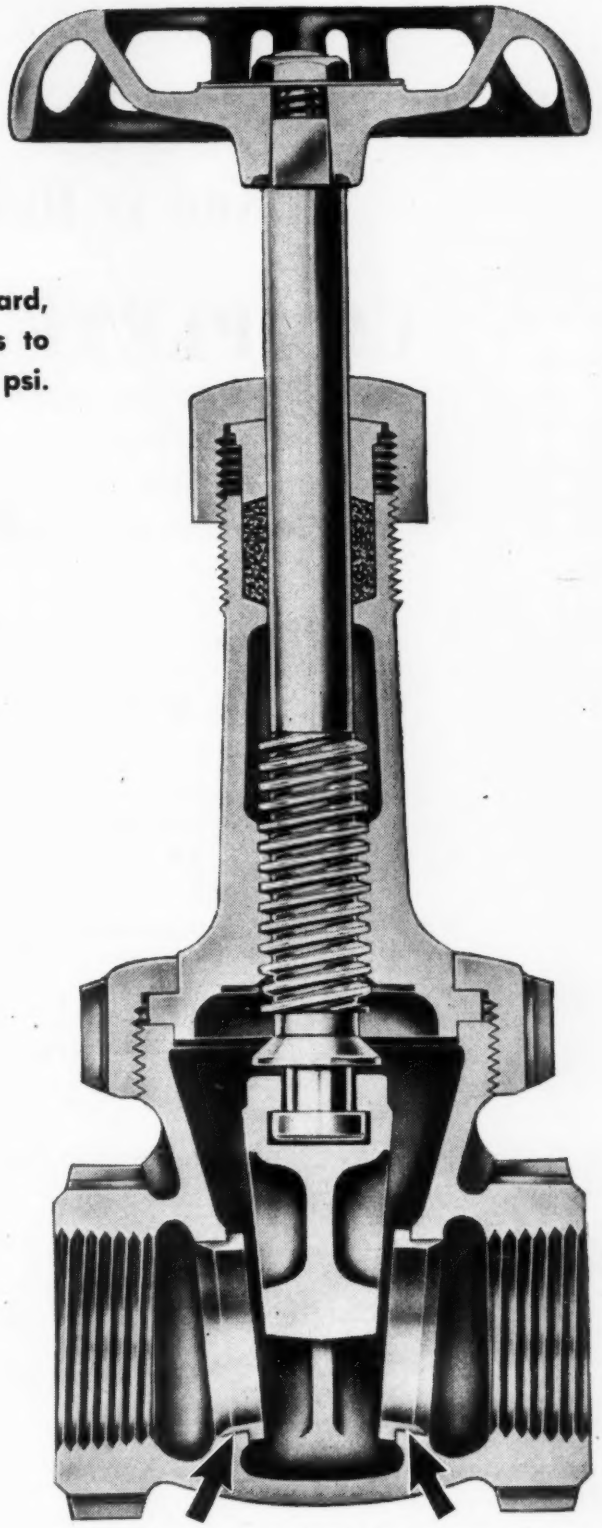
What's *your* metal problem? If it's hardness, corrosion resistance, strength, heat resistance, or a combination of these, it will pay you to find out more about Monel and the other INCO Nickel Alloys.

With INCO, solving metal problems is a privilege. Write us, and we'll assign a member of our Technical Staff to consult with you and recommend the metal best suited to meet your individual needs. *Reg. U. S. Pat. Off.



Cross section of new Jenkins valve. Arrows indicate wrought Monel seat rings expanded into valve body which resist wear and corrosion. Tight-fitting bronze wedge is easily replaced, enabling valve to last indefinitely. Available in ¼" to 2" sizes to handle 200 psi steam or 400 psi water, oil, or gas.

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FEBRUARY, 1948

COST OF MAKING HIGHER OCTANES

Program for Plant Capacity Expansion Now Confronting Refiners Also Means Significant Improvements in Antiknock Quality Will Require Several Years More, Automotive Engineers Told

The fact that material increases in octane numbers of motor fuels may be several years off, and will require relatively higher plant investments by refiners, should cause automotive engineers to direct their efforts to improve by design changes the utilization of antiknock qualities of present fuels.

This message was presented to the annual meeting of the Society of Automotive Engineers, in Detroit, Jan. 12-16, by W. M. Holaday, Director of Socony-Vacuum Laboratories.

The refining and marketing branches of the oil industry will spend $1,500,000,000 in the next few years in facilities to meet the quantity demand for products of present quality, he told the SAE. However, limitations in material and equipment and a shortage in skilled construction workers will curtail the amount of equipment that can be installed in any one year under this program.

After this present refinery expansion program is completed, further improvements no doubt will be made to improve the antiknock qualities of motor gasolines, said Mr. Holaday, but it will require several years more to install the required equipment.

Rather than to depend solely upon increases in octane values for improved economy, he said, engineers of the automotive industry should examine the manner in which the antiknock quality of present gasolines is being utilized. Any design changes which lead to full utilization of fuel antiknock qualities will result in improved economy.

That portion of Mr. Holaday's paper describing the cost to refiners of improving octane numbers by new processing methods is published here in a slightly abridged version. Title of the paper is "The Efficient Production and Utilization of Motor Gasolines."

By W. M. HOLADAY
Director,
Socony-Vacuum Laboratories

ECONOMIC factors are of primary importance in determining what can be done in the manufacture of more and better motor fuel. Therefore an attempt will be made to parallel the processing information with an indication of the accompanying investment costs. Obviously, no detailed economic analysis can be undertaken in the present paper and it must be realized that the investment cost data presented constitute, at best, only reasonable estimates.

In addition, no attempt is made to take into account the variation in operating costs from one processing scheme to another. However, it should be noted that, as more processing equipment is added to the refinery, more fuel must be burned to provide the heat required for the additional processing. This represents an increased usage of national resources regardless of the type fuel burned.

Prior to World War I, all refineries were straight-run units and even today a considerable number have no other facilities for producing gasoline. Processing equipment of this type for 100,000 b/d of crude oil can be built today for about $16,000,000. The gasoline produced will have an octane number of about 68/70 (Motor Research) with 1 cc. TEL per gallon.

To meet the increased demand for gasoline, thermal cracking was added to many refineries. A 100,000 b/d refinery of this type (straight-run refining plus thermal cracking and vapor recovery,) will cost about $24,000,000 and the gasoline octane number will be about 71/74 with 1 cc. TEL per gallon. The additional investment and operating cost for thermal cracking need not be charged entirely against increased octane number since increased gasoline volume—at the expense of heavy fuel oil volume—also results.

In order to improve the octane number and volatility of the gasoline, thermal reformers were added. A 100,000 b/d refinery of this type (straight-run refinery and thermal cracking plus thermal reforming) will cost about $26,000,000 and the gasoline octane number will be about 77/82 with 1cc. TEL per gallon. The increased investment and additional operating cost for reforming must be charged to higher octane number and improved volatility since the product value is decreased by breaking part of the straight-run gasoline into gas and converting part into fuel oil.

In order to produce more gasoline and improve the octane number, catalytic polymerization was added in many refineries. A 100,000 b/d refinery of this type (straight-run refining, thermal cracking and reforming plus catalytic polymerization) can be built today for about $27,500,000 and the total gasoline will have an octane number of about 78/83 with 1 cc. TEL. The improved product value arising from the conversion of part of the fuel gas into gasoline will usually pay for the additional operating cost and give a reasonable payout on the additional investment for catalytic polymerization, so that these increased costs need not be charged

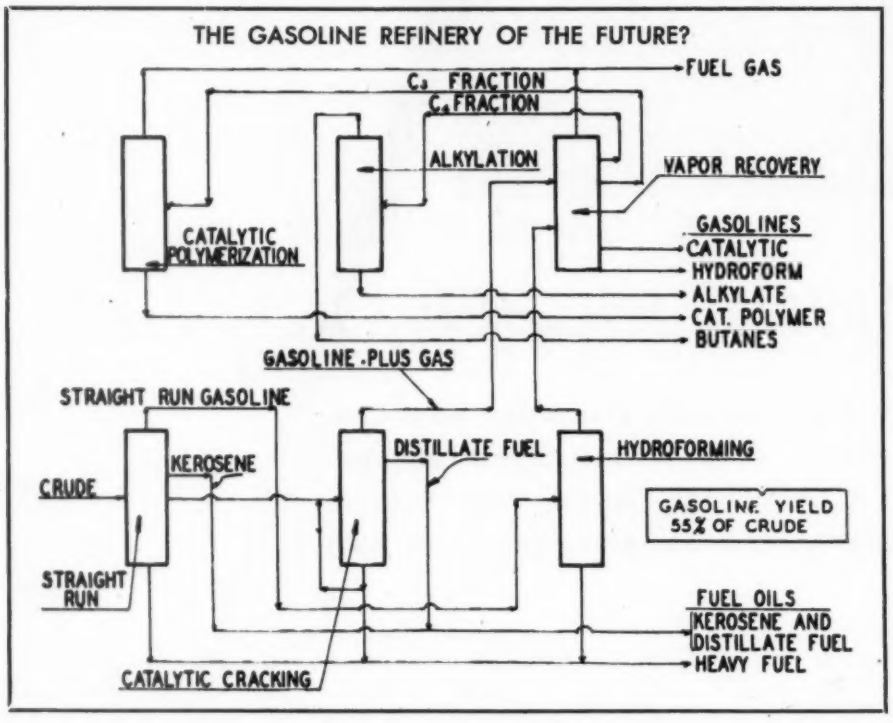


Fig. 1—Hydroforming all straight-run gasoline and doing all cracking catalytically

entirely against improved antiknock quality.

Because of the necessity for making large volumes of aviation gasoline during the war, most of the larger refineries added catalytic cracking and alkylation. A 100,000 b/d refinery of this type (straight-run refining, thermal cracking and reforming and catalytic polymerization plus catalytic cracking and alkylation) is markedly expensive when compared to the cost of the processing schemes previously considered, and will require an investment of about $65,000,000. The octane number of the total gasoline produced will be about 84/92 with 1 cc. TEL. Catalytic cracking and large scale alkylation has usually increased the product value enough to pay for the additional operating expenses and give a reasonable payout time on the increased investment. This cannot be said of small scale alkylation.

In order to produce still higher octane numbers, many refineries now substitute polyforming or hydroforming for thermal reforming. Both of these processes produce higher octane number gasoline than thermal reforming for the same loss in gasoline volume. Polyforming has the additional advantage that it can convert the heavier parts of the refinery fuel gas into gasoline, thereby eliminating the need, in some cases, for catalytic polymerization and alkylation. Hydroforming has the additional advantage of desulfurizing the gasoline and therefore is of particular value in reforming high sulfur naphthas.

A refinery using the preceding processing techniques and adding hydroforming for the high sulfur naphtha (thermally reforming only low sulfur naphtha), can be built today for about $72,000,000. The gasoline will approach an antiknock quality of 85/93 with 1 cc. TEL. Since both polyforming and hydroforming are reforming processes, the increased operating cost, investment, and decrease in product value must be charged against improved octane number and volatility.

Looking far into the future, it is possible to visualize a total refinery gasoline having an octane number of about 89/99 with 3 cc. TEL per gallon or about 87/97 with 1 cc. TEL by hydroforming all the straight-run gasoline and doing all cracking catalytically as shown in Fig. 1. Such a refinery will cost about $90,000,000 for 100,000 b/d of crude oil capacity. About 20% of the straight-run gasoline will be lost in hydroforming and the operating expenses will be very high.

From these data it can be seen that, in general, cracking processes and those converting the heavier parts of the fuel gas into gasoline produce low cost octane numbers since the product value is increased. In contrast, the reforming processes produce high cost octane numbers since product value is decreased. Fig. 2 indicates the gasoline yield, expressed as liquid volume per cent of crude, and octane number of the fuel as the additional operations that have been discussed are included in a refinery's processing scheme. The effect on the yield of fuel oil fractions (kerosine, distillate fuel, and residuum) is also shown. The major factor in increased gasoline yield results from catalytic cracking which utilizes mostly distillate stocks. The effect on the availability of straight-run diesel fuel and fuel oil fractions should be apparent.

Fig. 3 shows a plot of the investment required for the refineries described against the octane number of the gasoline produced by these refineries. The investment required for today's octane numbers is high and will increase rapidly if higher antiknock quality gasolines are required.

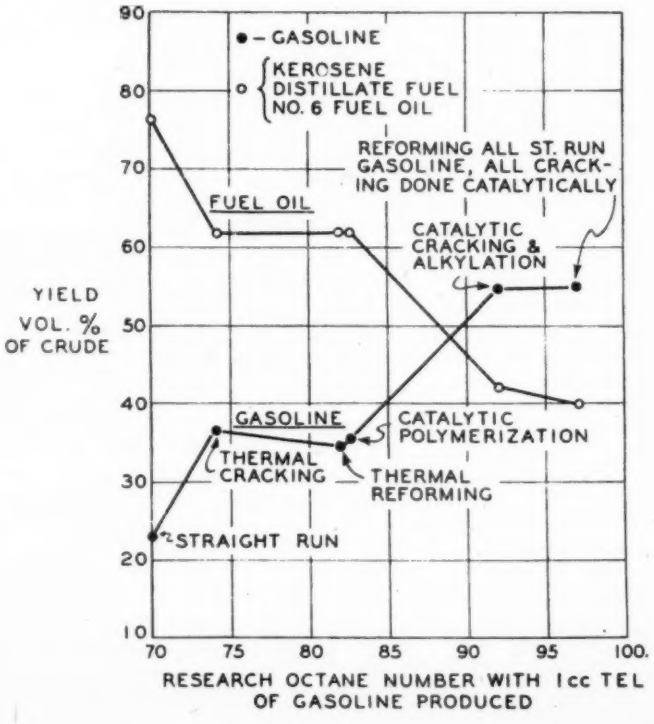


Fig. 2 — Gasoline yield and octane number as additional operations are included in a refinery's processing scheme. Effect on the yield of fuel oil is also shown

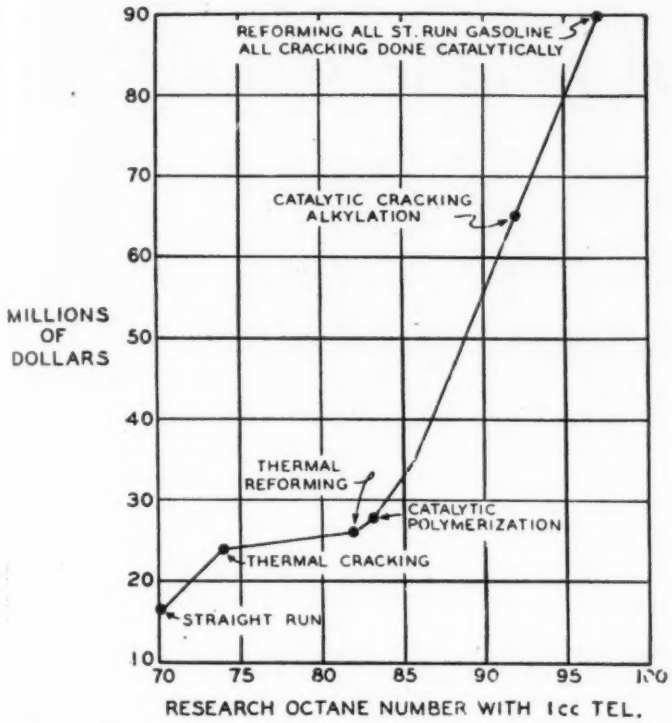


Fig. 3—Investment required for refineries with various processing operations plotted against octane number of gasoline produced

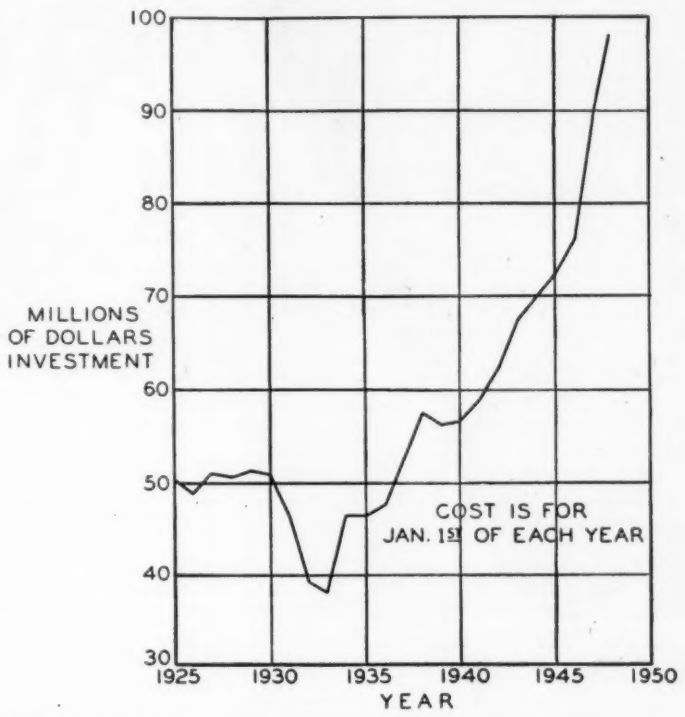


Fig.4—Graphic illustration of how construction costs have risen over past 20 years

There are available rather impressive figures to prove this fact. During the war years $927,000,000 were expended on major projects in refineries. Of this total amount, $864,000,000 were spent only on facilities for the production of 100-octane number aviation gasoline. The construction of catalytic cracking units accounted for the largest part of the investment, alkylation units a smaller portion, and lesser amounts for crude fractionating units.

Charging capacity to catalytic cracking units increased to over 1,000,000 b/d. What was the effect of this huge expenditure for quality producing equipment on the octane number of motor gasoline? Between 1941 and 1946, premium and regular grades increased *barely* 3 *octane numbers* in spite of the fact that aviation fuel production had been largely diverted to motor gasoline by 1946. In other words an increase in overall fuel antiknock quality of one octane number did cost then in the neighborhood of $300,000,000.

Fig. 4 illustrates how construction costs have risen over the past 20 years. Using these data as a basis, investment cost per octane number at present are about 50% above the average of the period 1941-1945. The investment figures on the various refinery installations previously cited were calculated several months ago and are undoubtedly 10% too low now—January 1948.

It is generally agreed that the refining industry must be expanded to handle another 1,000,000 b/d of crude in order to meet the anticipated demands, here and abroad, for petroleum products in the next few years. This expansion in refining equipment maintaining today's quality level and the required increase in distribution facilities will cost the industry about $1,500,000,000 at today's prices, and following current price trends, considerably more at the time of installation. An outlay of over $2,750,000,000 will be required to find, produce, and distribute the additional crude oil to fill these demands. This total investment exceeding $4,250,000,000 must be made to meet the anticipated demand for petroleum products and must, therefore, receive priority over investments aimed solely at improving the quality of products.

W. M. Holaday

In addition to the limitations imposed by this huge expenditure to bring the production level of the petroleum industry up, there is a limit to the amount of refinery and crude producing equipment which can be installed in one year. Among the shortages causing this limit are steel, motors, pumps, compressors and skilled construction workers. Consequently the expansion in refining and crude producing capacity will take several years. It should be noted that, during the war years, refinery expansion proceeded at a rate of only $250,000,000 a year. After the expansion is completed, further investments will no doubt be made to improve the antiknock quality of motor gasoline—but this will require several more years.

The fact that significant increases in the octane number of motor fuels may be several years off should not in any way impede the progress that the automotive industry can make in designing and producing engines and cars with improved performance and economy. It is felt that a critical examination of the manner in which antiknock quality is utilized in present-day cars, and of the effect that various design changes may have on antiknock requirements, will point the way to the goal desired by both the petroleum and automotive industries as well as the passenger car operator.

R. J. S. PIGOTT

First Oil Man to Head SAE

WHILE well known for his research in petroleum product utilization, it is his achievements in mechanical engineering that brought R. J. S. Pigott the presidency for 1948 of the Society of Automotive Engineers. He is the first direct oil company representative to hold this important office.

Mr. Piggott—the initials stand for Reginald James Seymour—since 1929 has been chief engineer in charge of engineering research for Gulf Oil Corp. and its subsidiaries. His previous experience includes 11 years in the design, construction and operation of central steam power stations; 7 years in designing and constructing power and industrial plants, office buildings, laboratories and garages; 5 years in metal-products manufacture and a year as professor of engineering at Columbia University.

Also an Inventor

In addition, he is an inventor of repute and holds more than 30 patents on devices used in hydraulic engineering, heating, oil production and other fields.

Appearing on several occasions on the programs for the SAE national meetings, his piquant, challenging papers have stirred up discussion on car design problems, particularly as affecting fuel and lubricant requirements. For example, his paper presented at the SAE annual meeting in 1944 under the title "Vapor Lock—or Dumb Engineering!" came at a time when automotive engineers were disturbed by vapor locking in aircraft and were proposing various involved theories in explanation. The paper presented the results of experiments to show that the basic cause was "inferior plumbing." The introduction stated the author was "about to kick the designers' shins."

Problem Isn't Abstruse

"The problem (vapor lock) has always been capable of concrete solution ever since we have had automobiles," said Mr. Pigott. "There is nothing in any way abstruse about it in spite of the experimental work that has been going on." Discussing the troubles from vapor lock in airplane engines during the war as altitudes went up he said:

"Aviation gasoline is excitable material, and almost any experimental drinker knows enough not to suck Vichy through a straw unless intending to produce 'burps' with a truly professional aplomb. Therefore, we ought not try and boil gasoline in the tank before starting to suck on it by means of fuel pump at the end of a long straw, usually carefully arranged with knots in it."

Why Oil Foaming?

When oil "foaming" became a problem in tanks and airplane engines under the severe wartime operating conditions, Mr. Pigott said in introducing a paper on this subject before the SAE in 1943: "The real reason why we have been in so much trouble from oil aeration (foaming) is that, until we flew high or ran tank engines badly cramped for decent location of accessories, almost nobody paid any attention to ordinary hydraulics in designing the oil supply system. Until the extreme conditions now experienced came in, almost any clumsily assembled tank, pipe and pump would oil an engine pretty well, but not now."

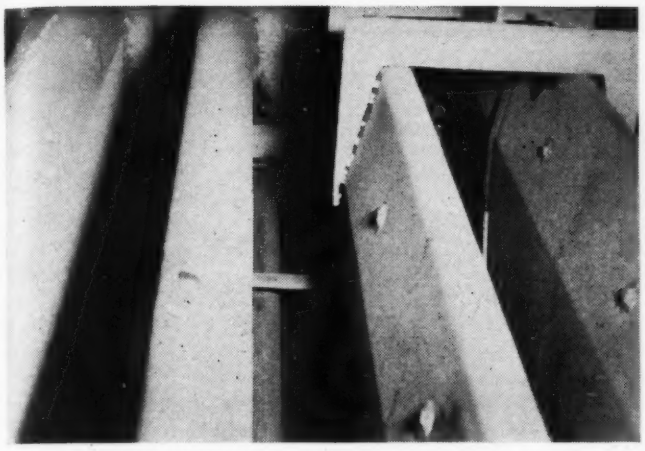
Mr. Pigott graduated from Columbia University with a degree in mechanical engineering in 1906, and, incidentally, in 1946 received the Columbia University Medal for his engineering achievements. After leaving school he served as chief draftsman, assistant engineer and consulting engineer for Interborough Rapid Transit Co.; as superintendent of construction for the New England Engineering Co.; as consulting engineer for Remington Arms - Union Metallic Cartridge Co., Sanford Riley Stoker Co., Bridgeport Brass Co., Public Service Production Co., Crosby Steam Gage & Valve Co., Gradon Manufacturing Co., Stevens & Wood, Inc., and other firms.

Chief Engineer for Gulf

As chief engineer for Gulf and its subsidiaries, he is responsible for this company's engineering research and design; laboratory buildings; operation of shops and drafting rooms; progress in the techniques, tools and equipment used in producing crude oil; design and fabrication of test equipment; solution of mechanical problems for the various company divisions; standard engine testing to qualify fuels and lubricants and the development of special equipment such as the "marsh buggy," piston ring pressure tester and aerosol sprayers.

Mr. Pigott was born Feb. 4, 1886, at Wellington, Shropshire, England, and received his early education in the New York public schools. He lives in Pittsburgh, his family comprising a son and three daughters.

Photos by John Henderson Studios



Only a small amount of erosion shows in this view of the air inlet distributor channel assembly and water cooling coils of an intermediate zone in the catalyst kiln

No loss of metal occured in the carbon steel internals of the reactor as shown in this view of a portion of the vapor-catalyst disengager tubes in the bottom of the reactor

Carbon Steel Gives Good Service In Processing Sour Crude Oils

Little Corrosion Found as Leonard's 3000 b/d TCC Unit At Alma, Mich., Undergoes Turnaround after an Initial 222-day Run on Reduced Crudes of about 0.9% Sulfur

LOW cost carbon steels will give good service in the processing of relatively sour crudes, recent turnaround tests revealed at the end of the first eight-month run of the new 3000 b/d TCC Unit at the Alma, Mich., refinery of Leonard Refineries, Inc.

Principal charge stocks were Reed City and Adams, Mich., reduced crudes which have sulfur contents of the order of 0.9 wt.-%. Corrosion and erosion inspections on the reactor indicated no loss of metal from the shell or internal metal elements, although all parts had been fabricated of carbon steel.

The new small-scale "cat-cracker", installed at the low cost of around $200-250 per bbl. of charge capacity, went on stream March 18, 1947.(1) Turnaround was begun Oct. 27, and the unit returned to service Nov. 6, 1947. Onstream efficiency during the initial 222-day run was 96.4%, as shown in Table 1.

Procedure Carefully Planned

Shutdown procedure at Alma was planned through conferences at the plant by representatives from Leonard and from Houdry Process Corp., which company engineered the TCC Unit and the accompanying changes to existing equipment.

A group of 40 men per day, two crews of 20 men each, completed the work of the turnaround during the 10½-day period with an expenditure of 4557 man-hours. Of the 40 men, 29 were from the refinery maintenance forces and 11 from the operating personnel of the unit.

Out of the total of 4557 man-hours, 2954 were spent on conventional refinery equipment such as valves, pumps, compressors, exchangers, and towers, and only 425 were needed for work on the catalytic section. Pertinent data concerning the man-hour requirements are presented in Tables 2, 3, 4, and 5. The major portion of the work was accomplished with unskilled labor, as illustrated specifically in Table 3.

Actually, two of the items of work performed during the shutdown do not come under the category of inspection and repair since they involved changes in equipment design for new processing procedures. These were piping changes in the steam superheater section of the vaporizing heaters, and the installation of liquid feed apparatus in the TCC reactor.

Charge Rates Were Upped

Recent reduced crude charge rates to the vaporizing heaters have been nearly twice the original design rates, and it was found that there was an excess of steam superheating capacity in the heaters. Therefore, during the turnaround, half of the steam superheating coils were connected in series with the convection section reduced crude coils to increase the heat input to the charge and at the same time reduce the steam superheating surface to the desired amount.

The liquid feed apparatus, which required slight modification of the reactor internals, was installed to permit the future processing of nonvaporizable stocks in the TCC Unit.

The man-hours required for these two design changes amounted to 496. As a result the grand total man-hours expended during the turnaround was 5053, 4557 for inspection and repairs and 496 for design changes.

In addition to the reactor, excellent service was obtained from other sections of the unit. In the catalyst kiln, a few panels of wall insulation showed a slight amount of erosion. These were repaired with a plastic type insulation. No mechanical repairs were needed on any of the air inlet distributing channels, flue gas collecting channels, or water-cooling coils in the kiln. Catalyst, air, and flue gas lines to and from

Houdry metal inspector calipers the return bends from the vaporizing heater tubes

the kiln were likwise found intact throughout.

Loss-of-metal measurements on the new split bucket-type catalyst elevator, a feature of the unit, showed that the elevator could be expected to operate a considerable time before a major overhauling was required. For example, total elongation of the chain during the eight months of operation was only 4 ins. equivalent to wear on each of the pin and bushing assemblies of a few hundredths of an inch.

The chain knuckles, which contact the traction rims and are subject to more severe wear, showed an average loss of metal of about 0.06 in., and the traction rims themselves had lost only 0.017 in. of thickness.

Wear was negligible in the new split-bucket type catalyst elevator used in Leonard's TCC unit

Among the auxiliary equipment, the three largest items of repair during the turnaround were the renewal of sections of the transfer lines between the heaters and tar separator, the renewal of the hot tar lines from the bottom of the tar separator, and the cleaning and adjusting of the wet gas compressors in the gas plant.

The overhead and bottoms products from the tar separator flash have average sulfur contents of 0.6 and 1.1 wt.-% respectively. Thus the sulfur content of the charge stock and fractions thereof have been sufficiently high that some corrosion was anticipated.

In the orginal design study of this TCC installation, it was recognized that alloy steel construction might be necessitated in many parts of the system because of the nature of the feed. However, a decision was reached at the time to use carbon steel in several places and determine by experience those critical points where the use of alloy steel was necessary.

As mentioned above, inspection results were gratifying in that severe corrosion was found only in the heater transfer lines and tar separator bottoms lines. Accordingly, during the turnaround, these lines were replaced with 4-6% chrome alloy steel pipe.

It was interesting to note that these lines operated within the critical temperature for corrosion by plant charging stocks. For example, the return line from the tar quench cooler to the tar separator showed no corrosion, whereas the other tar lines, which operate above 600° F., were severely corroded.

The wet gas compressors required thorough cleaning of both the power and compression sides. There were heavy sulfurous deposits on the suction valves of the compression cylinders from the hydrogen sulfide content of the gas processed.

Slight Pitting in Separator

The inspection of the gas and water separator tank revealed a slight pitting on those portions of the shell which are in contact with the water layer. This condition was corrected by sand blasting the lower half of the horizontal 10 x 40 ft separator and coating it with a protective plastic paint.

This equipment is considered to be the most unconventional of the plant. Instead of passing overhead vapors from the synthetic crude tower through conventional shell and tube condensers, a direct-contact, barometric type condenser is used. The cooling water and hydrocarbon streams are discharged into a tank

TABLE 1—Onstream Efficiency Summary

Cause of Off Stream Time	Hours	%
Stabilizer Clean-Up	48.0	25.1
Blower Maintenance	41.3	21.6
Circulating Water Pump Failure	63.7	33.4
Power Failures	26.7	14.0
Clay Hold-Up in Reactor Seal Leg	11.3	5.9
Total	191.0	100.0
Total Hours On Stream 3-18-47 to 10-27-47	5140.2	
Total Hours Elapsed 3-18-47 to 10-27-47	5331.2	
On Stream Efficiency		96.4

TABLE 2—Man-hour Requirement for Entire Plant by Job Item

Job Item	Manhours	%
Turnaround		
Inspection and Adjustments to Catalyst Elevator	75	1.7
Miscellaneous Work on Kiln and Reactor	350	7.7
Sandblasting Gas and Water Separator	285	6.3
Painting Inside Gas and Water Separator	48	1.1
Replacement of Tar Separator Bottoms Lines	501	11.1
Replacement of Heater Transfer Lines	344	7.5
Miscellaneous Work on Valves, Pumps, Instruments, Electrical Equipment, Gas Compressors, Heat Exchangers, Coolers, Fractionating Towers, Etc.	2954	64.6
Sub Total	4557	100.0
New Installation and Revisions		
Liquid Feed Installation	275	
Steam Superheater Piping Changes	221	
Total	5053	

TABLE 3—Man-hour Requirement for Entire Plant by Craft

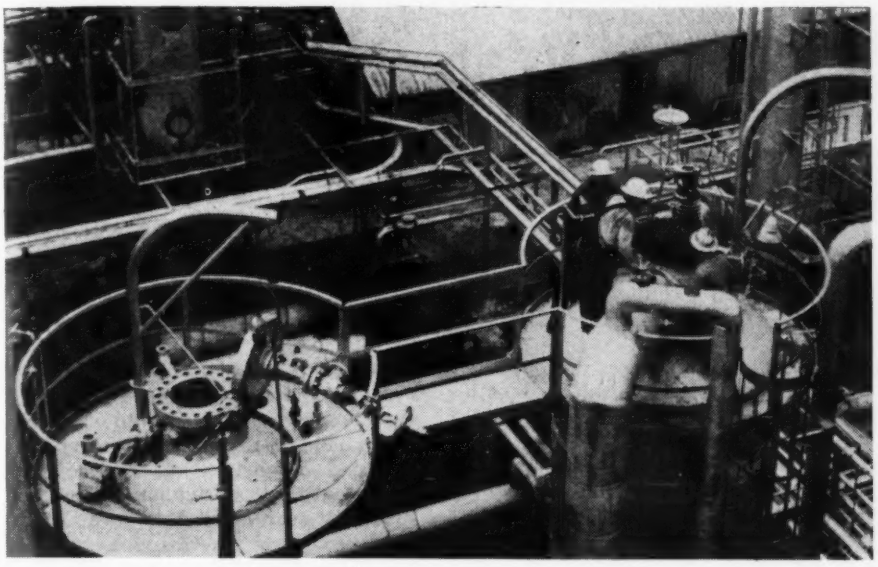
Craft	Manhours	%
Turnaround		
Welders	200	4.4
Machinists	912	19.9
Instrumentation and Electrical	216	4.8
General Labor	3229	70.9
Sub Total	4557	100.0
New Installation and Revisions		
Welders	302	
Machinists	40	
Instrumentation and Electrical	4	
General Labor	150	
Total	5053	

TABLE 4—Man-hour Requirement for Catalytic Section by Job Item

Job Item	Manhours	%
Turnaround		
Unheading and Heading Vessels, Etc.	144	33.9
Elevator Inspection and Adjustment	75	17.6
Reactor Clean Up	72	16.9
Repairing Flue Gas Compressor	30	7.1
Instrument and Electrical Maintenance	24	5.6
Circulating Water Pump Inspection and Repair	18	4.2
Kiln Insulation	16	3.8
Steam Drum Clean Up	12	2.8
Kiln Clean Up	10	2.4
Make Up Water Pump Repair	8	1.9
Miscellaneous	16	3.8
Sub Total	425	100.0
Liquid Feed Installation	275	
Total	700	

TABLE 5—Man-hour Requirement for Catalytic Section by Craft

Craft	Manhours	%
Turnaround		
Welders	38	9.0
Machinists	85	20.0
Instrumentation and Electrical	24	5.6
General Labor	278	65.4
Sub Total	425	100.0
Liquid Feed Installation		
Welders	180	
Machinists	36	
General Labor	59	
Total	700	



Acidizing of the Leonard TCC unit absorber was the only tower maintenance performed during the turnaround. Workmen are removing the top head from the tar separator for inspection

where separation of the condensed gasoline and water takes place.

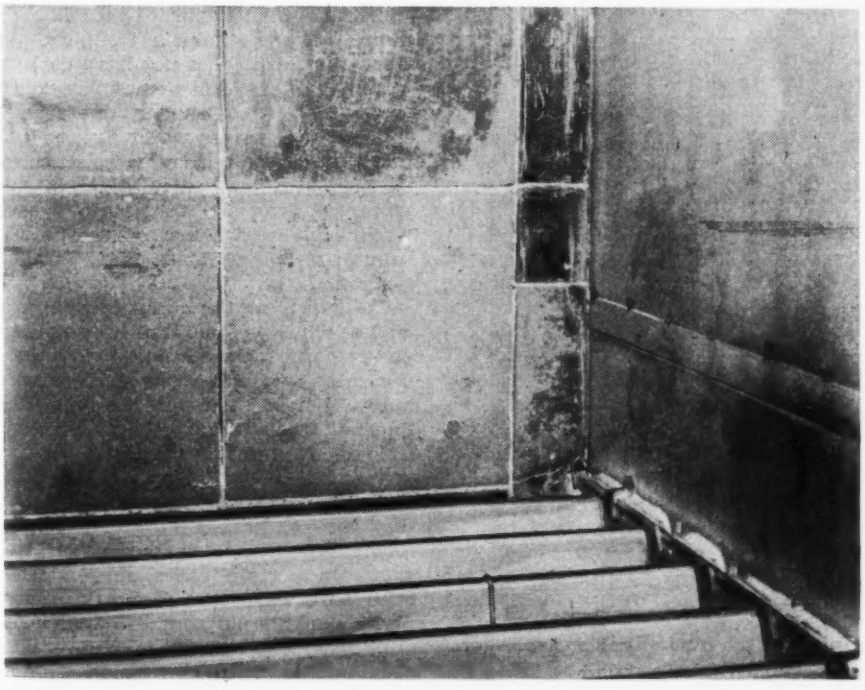
Based upon the experience of other refiners, the amount of hydrogen sulfide in the overhead vapors probably would have necessitated retubing bundles in conventional condensers after eight month's operation. At the present time it is fully expected that the barometric type condenser and the separator tank will last the life of the unit and require only very minor repairs.

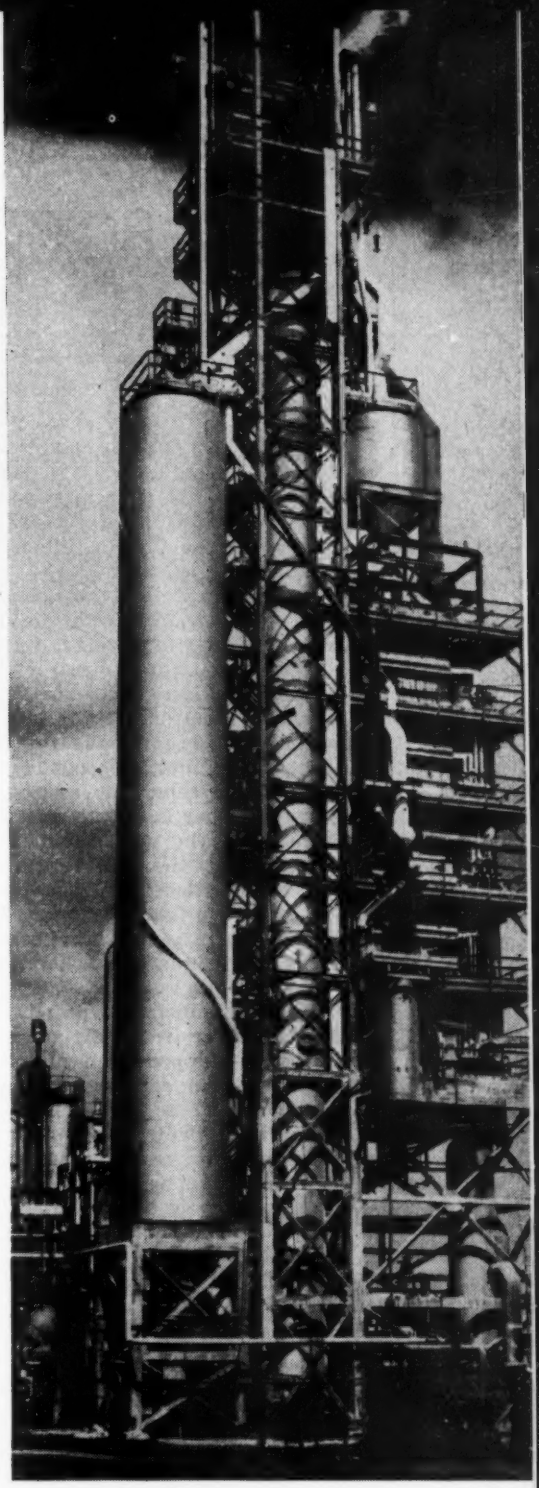
A nominal amount of pump maintenance was required. Serious corrosion, similar to that which occurred in the hot tar lines, had also occurred in the hot tar pump, necessitating the replacement of fittings in the liquid end of the pump. Other pumps required routine servicing and some, because of their excellent performance during the intial run, were not even opened for inspection.

Essentially no instrument maintenance was needed. A large percentage of the man-hours expended in instrument servicing during the turnaround was for replacing orifice plates to accommodate the higher charge rates which have been and will be maintained.

Reference

(1)--See PETROLEUM PROCESSING, June, 1947, pg. 411, "8000 b/d Refinery Converts Thermal Unit to Catalytic Cracking for $200-250/bbl." by William F. Bland.





Leonard Refineries' 3000 b/d Thermofor catalytic cracking unit, which completed a 222-day initial run on relatively sour crudes with onstream efficiency of 96.4%

Part of internal wall insulation in the bottom zone of the TCC kiln; flue gas collector channel assembly below

This article is based upon information describing the turnaround of the TCC Unit at Alma, Michigan, by Mr. John S. Pfarr, Technical Director, Leonard Refineries, Inc.

New 80,000 gpm Oil-Water Separator Deviates from Conventional Design

By LOGAN ROSS
General Engineering Division
Standard Oil Co. (Ohio)

NEW oil-water separator facilities capable of handling 80,000 gallons per minute of waste water and costing over $750,000 have recently been installed at the Toledo refinery of Standard Oil Co. (Ohio).

Although designed on the same basic principle of separation by gravity differential used in the standard API oil-water separator, the new Sohio separator differs in some respects from conventional units.

The usual API design calls for a primary chamber and a secondary chamber for each separator section, the primary chamber including a film rupture tray. In the new Sohio installation, however, the film rupture tray is replaced with a straight weir plate, and only one chamber is used for each of the 20 separator sections, with a common influent channel serving all of them.

These single chambers perform the final oil and sludge removal operations, and are equipped with an oil skimming and sludge scraping device in the same manner as the API primary chamber. They are longer, however, than the usual primary chamber, about as long as the secondary chamber would be.

The entire installation covers 10.2 acres. In addition to the distribution channel and 20 separator sections, it includes a sludge pond of approximately 3 acres, two 2100-bbl. storage tanks for recovered oil, pump house and office, and fire protection system. The layout of these facilities is shown in Fig. 1.

One interesting feature of the new facilities is that they are designed to accommodate the waste water of both Sohio's refinery and that of Pure Oil Co., which has a plant on adjacent property. The waste waters from both plants are collected into a common culvert which carries them to the separator.

In operation, waste water from the refineries flows through the culvert and into the common distribution channel. Here some of the sludge settles to the bottom and is periodically pumped to a sludge pond. The waste water then enters as many of the 20 separator sections as are in operation, passes over a weir, and flows the full length of the section. During this period oil rises to the top and sludge settles to the bottom. The oil on top is skimmed off, flows by gravity through an oil collector system to pumps, and is pumped into the storage tanks. The sludge is scraped into sludge hoppers at the upstream end of each chamber, and pumped to the sludge pond. The clear effluent from each chamber flows into a collector channel and is disposed of without further treatment, passing into a nearby creek which carries it into Lake Erie.

Reasons for New Separator

There were several fundamental reasons for the construction of these facilities. In the first place, existing separator facilities had been built in 1920, and were designed for a much smaller throughput than is now required. In addition, it was necessary to improve the quality of the refinery's waste water in order to fully conform with all anti-pollution laws.

On top of all this, Sohio had recently sold to the Baltimore and Ohio Railroad a portion of its property, including that on which the old oil separator was located. It was therefore necessary to abandon the old separator and build a new one.

Waste Water Flow Quantities

In order to design a new separator system, it is necessary to determine the quantities and types of water to be handled. Since this installation at Toledo is used jointly by both Pure Oil and Sohio, this problem became rather complex.

Through various surveys and studies, it was determined that Sohio's Refinery uses about 29 to 30 thousand gpm. of process water. By the same methods, Pure's Refinery uses between 5 and 6 thousand gpm. This means that the new separator facilities had to be designed to handle an average of 35 thousand gpm. of process water, which is about equivalent to one-third of the water used by a city of a million population.

Pure's Refinery is so arranged that most of its cooling water is re-circulated through cooling towers. Its cooling tower blowdown water leaves the refinery and empties into Sohio's main culvert. Sohio's Refinery, on the other hand, does not have cooling tower circuits but employs "once through" cooling water operations. After these process water figures had been established, they were verified by means of flow calculations of the water flowing in the main waste water culvert by use of recognized roughness co-efficients and velocity tests.

To determine the quantity of storm water which might be expected to enter the refinery sewer systems during rains, a complete inspectoin was made of both Pure's and Sohio's Refineries. In addition to this inspection, a complete analysis was made of the properties' topographic map. The purpose of these steps was to arrive at the portions of land which sloped toward the sewer system catch basins. In certain cases, on undeveloped portions of the property, storm water can not be contaminated with oil. This water flows in a direction of county road culverts which are not

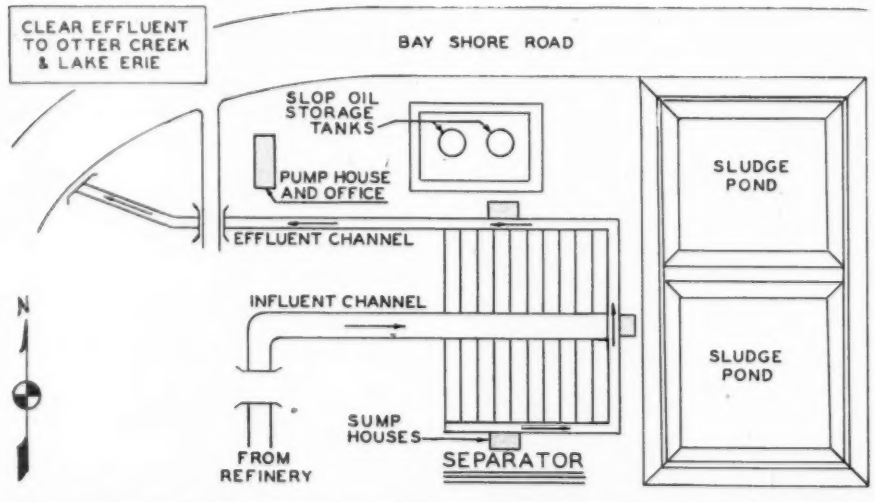


Fig. 1—General plot plan of the facilities included in the new oil-water separator installation at the Toledo refinery of Standard Oil Co. (Ohio)

collected by the refinery's sewer system.

The figures on the quantities of water which were used for the design of the new separator are summarized in Table 1. It can be seen that the process water design flow was 35,000 gpm., and the storm water design flow, 45,000 gpm., making a total possible design flow of 80,000 gpm.

Waste Water Characteristics

In addition to the quantity of waste water to be handled, it was necessary to determine other factors which entered into the design of the separator. These items were obtained by laboratory tests. Sampling and testing of the waste water were performed by members of Sohio's Technical Service Division and the Process Engineering Group of its Toledo Refinery. In general, sewage samples were taken of the separator influent and effluent including the total flows from the Pure and Sohio Refineries. These samples were procured under both winter and summer conditions over a period of four years prior to actual construction of the separator.

The following figures, based on actual field samples and laboratory tests, are the ones finally arrived at as the basis for the separator design:

Turbidity, 400 parts per million.

Average low temperature of water, 70°.

Average low gravity of the oil in the waste water, 23° API.

In summarizing this data, it should be stressed that the lowest or worst conditions were not used because of economic considerations. However, reasonably low averages of water temperature and oil gravity were utilized to arrive at an economical yet conservative design.

Design Basis

Before discussing the design basis of the new separator, it should be mentioned that it was developed during a period when a large volume of work was being handled by Sohio's General Engineering Division's Design Section on projects essential to the war effort. Therefore, it was decided that the engineering work for this project would be done by the Arthur G. McKee Co. All data, initial designs and calculations which had been preliminarily developed by the General Engineering Division were made available to McKee, and this firm prepared the hydraulic designs and completed all of the engineering drawings.

As pointed out in the earlier section of this article, the Toledo separator does not follow exactly the design of the conventional API oil-water separator.

Five API design separator sections were placed in complete operation in 1945 at Sohio's No. 1 Refinery at Cleveland. In the light of actual full-size plant operation, it was felt that certain features of these units could be improved. The film rupture tray which contained Raschig rings tended to clog and become ineffective. Further, the oil removal pipes could be so adjusted that at times an excessive amount of water was introduced into the skimmed oil system. On the new Toledo separator, these items were improved by the use of a straight weir plate and an automatic skimming device.

It is believed, however, that the basic principle of separation by gravity differential is sound. This principle as developed in the API symposium on "Disposal of Refinery Wastes —Section I: Waste Water Containing Oil" was followed, with modifications, in the design of this project.

Fig. 2 shows a cross section of Toledo's new separator. The waste water enters 20 separator sections, 10 on one side and 10 on the other side of the influent channel. The water passes through 60 manually-operated sluice gates. Three of these gates are located on each section. After the water flows through these

This Month's Cover Picture

Photos by F. Price, Toledo

Aerial view of the entire separator project at Standard Oil Co.'s Toledo refinery, looking east. The inlet channel is shown in the lower right corner, and the outlet channel just left of bottom center. The two sludge ponds are in the background, slop oil storage tanks just left of the separator itself, and the pump house in the lower left corner. Although the separator was in operation at the time this photo was taken (Sept. 24), final clean-up work was just being completed

TABLE 1—Data on Separator Design Capacity

Process Water:	
Sohio Refinery, 29-30,000 gpm	
Pure Refinery, 5-6,000 gpm	
Total Average, gpm	35,000
Storm Water Run-off, gpm	45,000
TOTAL Design Flow, gpm	80,000

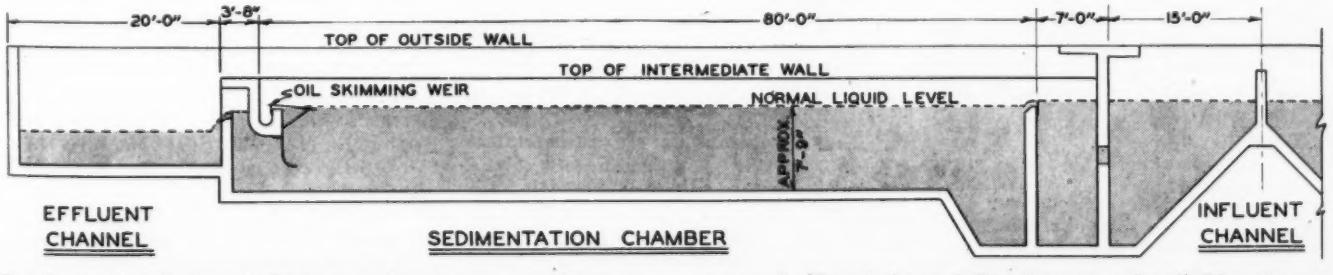


Fig. 2—Sectional view through one side of the new oil-water separator, showing the influent channel, sedimentation chamber and effluent channel. Not shown are the oil skimming and sludge scrapping unit and the rails on which it rides

View of inlet channel, which serves as the primary section of the separator, looking toward the inlet end. Note the skimming unit at the far end

gates, it gravitates into a distribution channel and then over a weir into the main section of the installation. After flowing through this section and under its end curtain baffle, the water overflows a weir into the effluent channel.

The API design calls for a series of calculations which determine the length, width and depth of a primary and a secondary section. The secondary section of the true API separator is equal to the length of the primary section times a factor of 1.4. Because of the large quantity of water to be handled in this installation, the complete application of the API design would have called for two sections with a total length 2/3 greater than that actually installed and would have been very costly. For economic and design reasons, the 20 main separator chambers were based on the API secondary section design. However, in this case the influent channel takes the place of the API primary section.

By applying the various data which were indicated previously to the type and quantity of waste water, the main section calculated to be 80 ft. in length with a depth of water in each section of 7.9 ft. In order to have sufficient capacity for a total flow of 80,000 gpm., 20 separator sections 18 ft. wide were used. During a normal flow of 35,000 gpm. of process water, the velocity of the water through each section is approximately 1.7 ft. per min. During abnormal storm conditions, this flow may reach as high as 3.7 ft. per min. It was felt that the abnormal storm conditions would exist so rarely that it would be uneconomical to design completely for this maximum period.

Special Design Features

Because the quantity of water to be handled requires 20 separator sections operating in parallel, water distribution to all sections was one of the first problems to be encountered. For this purpose a central split channel 29 ft. wide was provided from which the water flows through submerged sluice gates into the distribution chambers. From each one of these chambers the water flows over a full width weir into the main separator sections.

The overflow weir mentioned previously tends to distribute the water evenly into the main separator chamber and it also assists in breaking up the oil globules in a similar manner as the film rupture tray in the conventional type separator. The film rupture tray filled with Raschig rings was not included in this installation for the reason that plugging conditions had been observed previously in these rings at other refineries, thus causing by-passing of the Raschig ring compartment. Provisions have been made, however, so that film rupture trays may be added if necessary at a later date.

Oil Skimmer, Sludge Scraper

An unusual type of unit has been employed for skimming oil off the top of the water layer in the separator and for scraping sludge from the bottom of the chamber. It is known as the Duplex Type Rectangular Clarifyer, and is manufactured by the Hardinge Co. of York, Pa. Although this type skimmer-scraper has been in use in sewage plants for some time, the Toledo installation is the first time it has been used in any refinery oil-water separator, as far as Sohio knows.

Eleven skimmers are installed in the separator. Each skimmer spans two separator sections, a total of 10 for the 20 sections, with the eleventh operating on the influent channel for the purpose of skimming oil from the water surface.

As this equipment travels up stream or toward the influent channel, the top skimmer remains out of the water while the bottom scraper carries sludge along the bottom of the separator basin and moves it into the sludge hopper situated on the floor of the main separator section. When the mechanism reverses itself mechanically by means of a stationary stop, the sludge scraper travels upward so that it is free from the bottom of the separator. The oil surface skimmer lowers into position to skim oil from the water surface down stream toward the effluent channel. As the unit reaches the oil trough apron, the skimmer pushes the free oil up the apron and into the trough. At the end of this operation, the carriage mechanically reverses itself and returns automatically to start a new cycle. The skimmers were designed for continuous operation, 24 hrs. per day; however, actual operating experience indicates that intermittent operation may be satisfactory. These units are equipped with a safety device so that if they are jammed and stop for any reason, the motor shuts off and an alarm sounds.

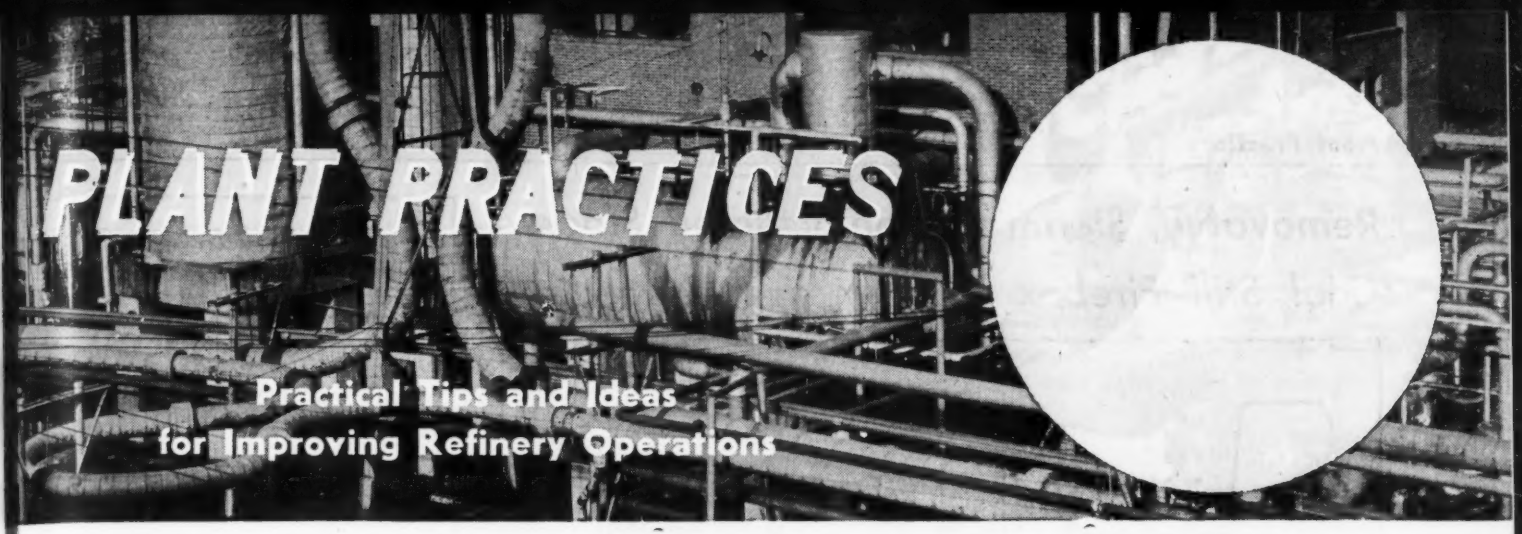
This reciprocating type of skimming equipment was chosen over the usual endless type of conveyor for several reasons. Maintenance problems will probably be less because more of the units' bearings ride above the water surface. The skimmer carries the oil in a more positive manner up the skimming apron into the skimmed oil trough, which requires less attention by the operator than does the usual rotating skimmer piping. Finally, it was found that the initial equipment and installation cost of the Hardinge units was less.

Operating Results

Since the new Toledo unit was put into operation last August, a close watch has been kept on it, and numerous laboratory tests of the influent and effluent have been conducted. These tests indicate that the operation of the installation is entirely satisfactory, and that it is performing even better than expected in reducing the oil and solids content of the waste water.

So far, operation of the separator has been at only partial capacity, since Pure's Toledo refinery was shut down by strike at the time the new separator was put into use, and is just now being put back on stream. The efficiency of the separator operation is not expected to change when the Pure plant is fully back to normal, however, since Pure's operations contribute only a minor amount of the waste water load.

It is felt that the results obtained to date with the new separator have gained the original objectives established by Sohio and all authorities concerned.



Special Tools Simplify Job of Removing Wornout Tubes from Heat Exchangers

TWO tools for quick, easy, and safe removal of tubes from condensers, coolers, and heat exchangers have been developed in the boilermaker department at the Marcus Hook refinery of Sun Oil Co., greatly simplifying both field and shop maintenance jobs on this type of equipment.

For replacement of a few condenser tubes, the stiffening tool shown in Fig. 1 was designed. A ¾ in. rod about 45 in. long is turned down to ⅝ in. diameter except for a 3 in. shoulder at one end. A ⅜ in. pilot rod by about 40 in. long is then welded at the shoulder end as indicated.

After the condenser tube has been cut free of the tube sheets, the stiffener rod is inserted and the tube drawn out. Use of the tool prevents the often paper-thin tube from buckling inside the condenser and jamming up among other tubes.

In Fig. 2 is shown a tool used for removing cooler or heat exchanger tubes. Tubes to be replaced are cut free of tube sheets and driven out 3 or 4 in. Then the tool, made of a fine grade tool steel and shaped like a butcher knife blade, is driven through the tube as indicated, a wire rope is hitched on and the tube pulled out with an air hoist.

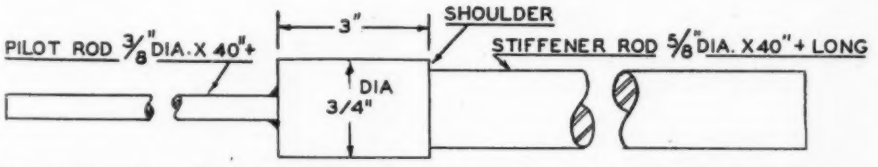


Fig. 1—Special tool for removal of corroded condenser tubes. Tool acts as stiffener, preventing paper-thin tubes from jamming up inside condenser

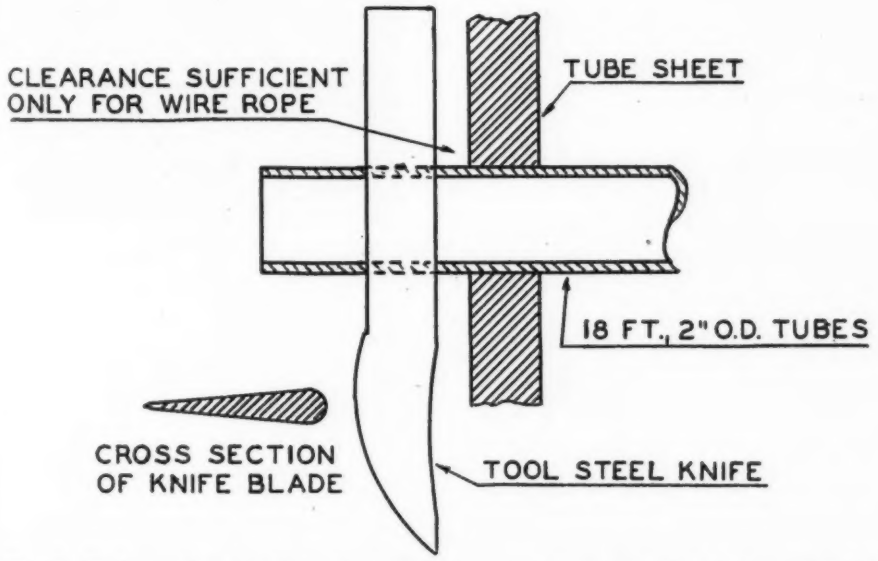
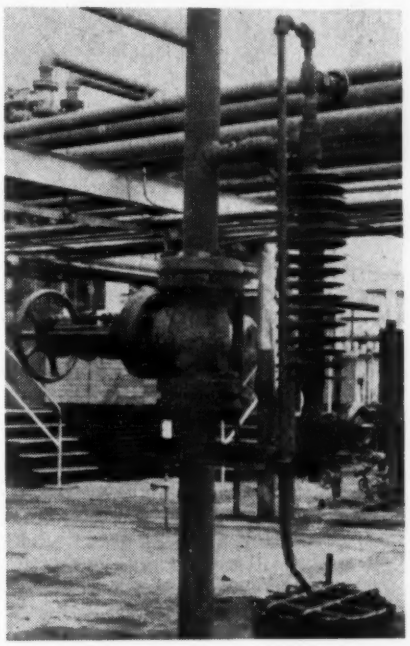


Fig. 2—Knife made of tool steel, used to remove heat exchanger tubes. Tube is driven out of tube sheet a few inches and knife is driven through then serves as hook for fastening hoist cable

Air-cooled Sample Line Useful For Hot Residua or Heavy Tars



Hancock Oil's air-cooled sampler attached to a hot residuum line

SAMPLES are safely drawn through an air-cooler from lines carrying hot residuum and heavy tars in the Long Beach, Calif., refinery of the Hancock Oil Co. The air-cooler, made in the shops by the plant welder, is a 2 ft. length of 1¼ in. pipe.

Cooling surface is provided by concentric rings, cut from ⅛ in. tank steel. They are perforated for close fit to the pipe and are welded in place on approximately one inch centers. The cooling unit is attached to the line from which the sample is to be removed as illustrated in the photograph.

The device eliminates the need for a water-cooled sampler and requires no attention or preliminary operation other than a thorough bleeding so as to obtain a true sample.

Removable, Steam Siphon-actuated Stacks Cool Still Firebox Quickly and Safely

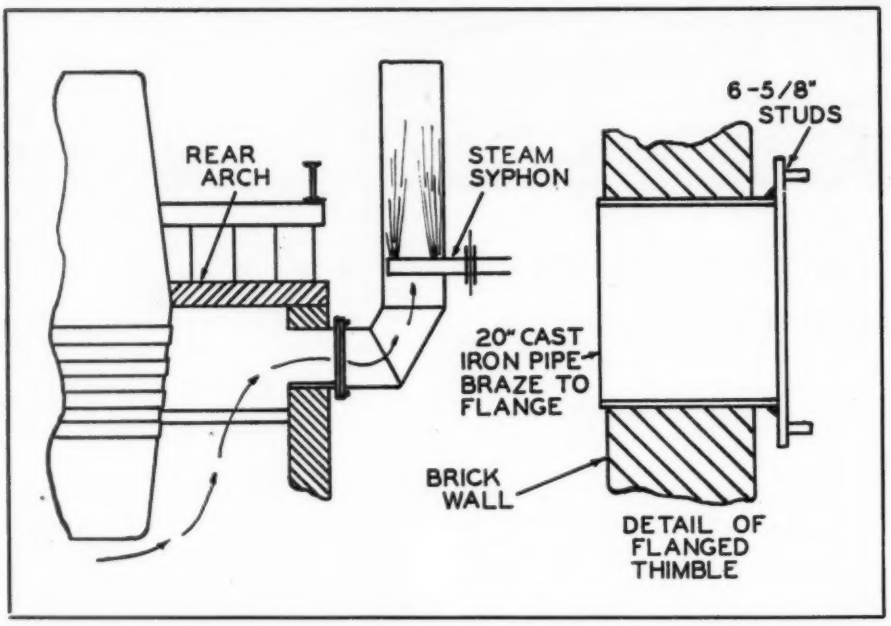


Fig. 3—Portable stack arrangement used to cool fireboxes in crude stills at Humble's Baytown plant saves time, improves safety, and gives men more space to work

COOLING fireboxes in stills and boilers to temperatures low enough to permit safe entry is often a long job with conventional fans or blowers. Also, repairmen may stumble into the fan or receive an electric shock from faulty cable or fan.

Humble Oil & Refining Co., at its Baytown, Texas, refinery, uses a portable draft stack and steam siphon as shown in Fig. 3 to quickly cool the fireboxes on its crude stills.

The stack comprises a 5-ft. length of sheet metal fabricated into a 20-in. diameter pipe, and a 90° ell, equipped with a small steam siphon. A hole is cut into the brick breeching to accommodate a 20-in. diameter cast iron pipe with a flange. When the still is in operation, this opening is loosely bricked up.

To cool the firebox, the stack is attached and the siphon started. Firebox doors at front are opened and air is permitted to circulate through the box. Since the fan is not needed, more room is available at the front of the still for men to work. This simple device was suggested by M. T. Ward, pipefitter. It has been used successfully since its adoption two years ago.

IDEAS—Wanted!

Plant operators, foremen, engineers, superintendents!—Send in your own original contributions on "how we do it around our refinery." Possible subjects could include operating shortcuts, time and money-saving gadgets, special repair tools, accident and fire prevention ideas. Include photographs, drawings, or charts, if available.

Material submitted for publication exclusively in PETROLEUM PROCESSING is paid for at the usual space rates. The idea is the thing—we'll dress up the drawings and the written information. Send your ideas to:

Plant Practices, Editor
PETROLEUM PROCESSING
1213 West Third St.
Cleveland 13, Ohio

Work on Tube Bundles Is More Efficient Through Use of Inexpensive Light Holder

AN INGENIOUS tube bundle light, developed by Charles A. Reynar, boilermaker at Shell Oil Co., Inc. Wood River refinery, is used in the shop to throw working light on tube ends undergoing installation or repair. Fig. 4 and the photograph show the inexpensive arrangement.

The mounting consists of a "C" clamp of convenient size, to the back of which has been welded a short section of rod. Over this rod is placed a "T"-shaped fitting, drilled and tapped as shown in the drawing to take two thumbscrews. Through the horizontal member of the tee is run a 3-ft. length of ¾ in. tubing, to one end of which is fastened a light socket and reflector. Wire for electrical connection runs through the tubing.

The "C" clamp is attached to the tube-sheet of the bundle, sufficiently tight to hold it firmly regardless of position of the light. By means of the two thumbscrews and adjustment of the light-carrying rod, the lamp may be positioned as desired, will not fall off, the wire stays out of the way and, with the proper reflector, light will not be thrown in the workman's eyes.

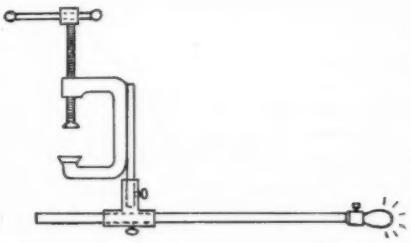


Fig. 4—Sketch of arrangement for adjustable tube bundle light. Charles A. Reynar of Shell's Wood River refinery demonstrates his handy tube bundle light in position to illuminate tube ends

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Modified Procedure Reduces Sample Size For Routine Cetane Number Determinations

By J. O. CHASE and A. D. PUCKETT

Petroleum Experiment Station, Bureau of Mines

Bartlesville, Okla.

THE Bureau of Mines has been engaged for the past year in a study of Diesel fuels which requires determination of ignition quality and a number of other physical and chemical properties on narrow-boiling fractions of approximately 0.5 volume per cent of the original fuel.

In order to make tests on narrow-boiling fractions and still maintain processing work at a minimum, it was necessary to analyze each test used with the view of reducing the volume of sample required without impairing the accuracy of the determination.

One result of the studies was the development of a modified test procedure and fuel system for the ASTM cetane-method engine which has made it possible to determine cetane numbers as a routine procedure on approximately 200-ml. samples and in special cases on 100-ml. These modifications have been used successfully for several months and have no effect on either the reproducibility or the level of ratings.

Equal Reproducibility

Examination of a large number of engine ratings by both the current ASTM D613-43T and the older ASTM D613-41T method revealed that the reproducibility of the 43T method, which required setting the combustion indicator gap three times while the engine is burning the test fuel at the rate of 13 ml. per minute, was no better than that of the 41T method which requires only one such setting.

Since elimination of two of these operations would account for a saving of the valuable samples in the order of 100 ml. per test without reduction in precision, it was decided that the 41T method should be followed in this respect. (It is understood that the ASTM has recently voted to return to the one-combustion indicator setting in the 1947 revison of the test procedure.)

Further efforts to conserve material resulted in the modifications of the test unit fuel system shown in Fig. 1. The object of the alterations was to reduce to a minimum the fuel losses occasioned by flushing the standard burette each time the engine is switched to the test sample. With the standard system, this use of fuel is necessary and accounts for an appreciable portion of that consumed during a test.

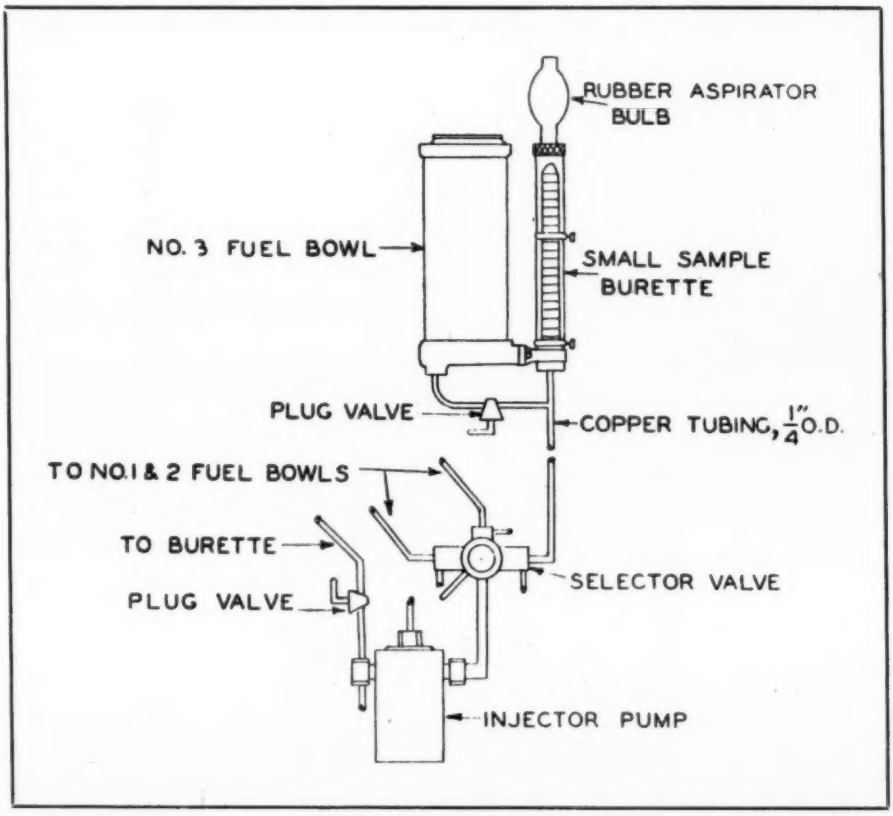
As illustrated, an additional burette was attached, by means of a blank flange, to the extreme right fuel reservoir in place of the usual gage glass. This burette was connected to the fuel bowl and to the fuel selector valve by means of ¼-inch o.d. copper tubing, and a valve was provided in the line to the bowl in order that fuel could be drawn from the burette only, providing a means of determining rate of fuel consumption when running on the sample.

A valve was also placed adjacent to the injection pump in the line to the regular burette so that it could be isolated from the system. The rubber bulbs shown are used to draw fuel into the burette when the fuel levels in the reservoirs are low.

Reference Fuels Run As Usual

With this arrangement, the bracketing reference fuels are run in the usual manner, and the standard burette is used to measure the rate at which they are consumed. When the engine is operated on the unkown sample, the valve to the standard burette is closed and the additional burette used to measure fuel rate. Thus the fuel normally lost through flushing the burette three times is saved. In addition, there is a small saving due to reduced hold-up in the system.

Fig 1—Modification of fuel system for improved Cetane-number test procedure developed at Bureau of Mines Petroleum Experiment Station at Bartlesville, Okla.



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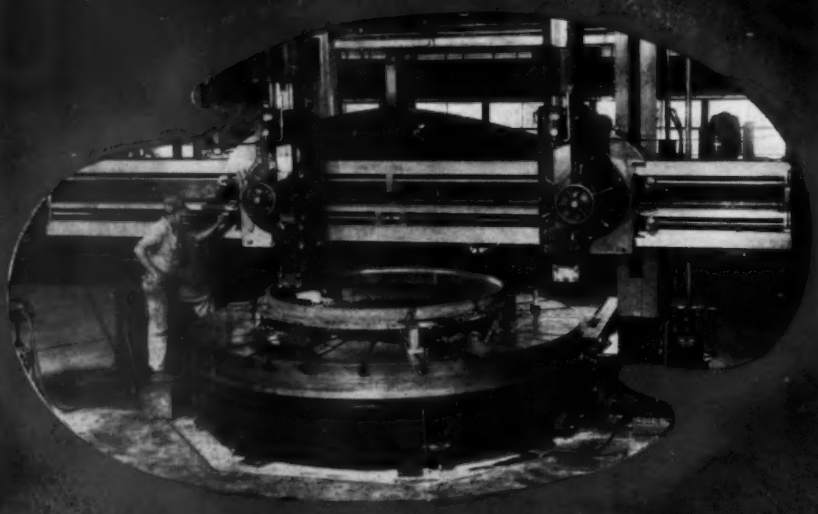

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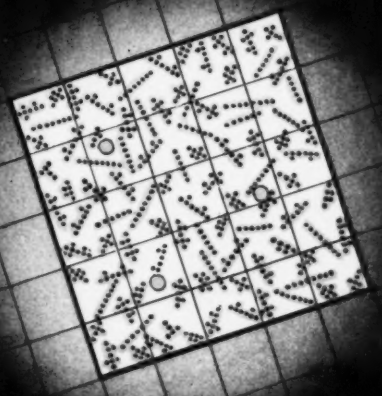

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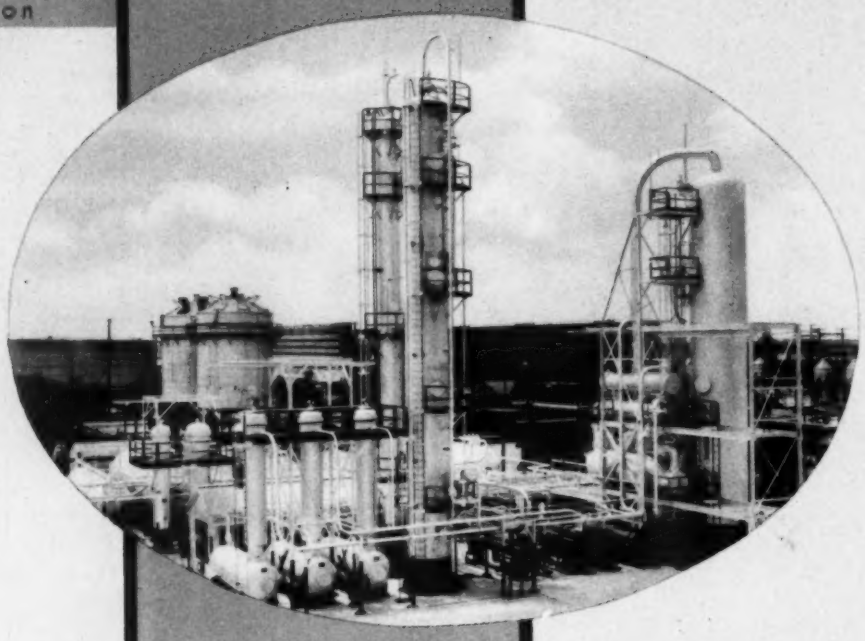

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Low-Temperature Carbonization of Coal Produced Most of Japs' Synthetic Oil

By C. S. GODDIN* and D. P. THORNTON, JR.**

Under the Japanese Seven-Year-Plan, adopted in 1938, annual production of 12,600,000 bbls. of synthetic gasoline and fuel oil was to be developed. Actual production achieved in coal hydrogenation, Fischer-Tropsch and low-temperature coal carbonization plants, however, was less than 750,000 bbls. in 1944, the greater part coming from coal carbonization.

Of the three coal conversion processes, a great deal of laboratory work was done on hydrogenation and without the aid of German scientists. A mixture of ferric oxide, sulfur and stannous hydroxide was chosen as a standard catalyst. Industrial hydrogenation was plunged into without sufficient pilot-plant experience. The Japs purchased rights to the Fischer-Tropsch synthesis from Germany, but a great deal of their research work was in an effort to find a cheap natural catalyst to replace the German cobalt-thorium mixture. A natural iron catalyst was discovered, yields, however, were much less than with the cobalt catalyst.

The Japanese recognized their nation's critical lack of an adequate petroleum supply for the long-contemplated national expansion which they knew would lead to war. Hence, as related in an earlier article(1), they built up a great stockpile of crude petroleum and refined products. They likewise labored long and intensively to develop an industry for conversion of coal into oil within the "Inner Circle" of their defenses.

Three coal conversion processes were studied and expanded into industrial scale; high pressure hydrogenation, the Fischer-Tropsch synthesis and low-temperature carbonization. Information obtained by the Petroleum Team of the U. S. Naval Technical Mission to Japan—NavTechJap(1)—indicates that coal hydrogenation was studied more thoroughly there, at least on a laboratory scale, than in any other country except Germany. This article reviewing the Japs' efforts to synthesize liquid fuels from coal is taken from Report No. 7 of recently declassified U. S. Navy reports entitled "Japanese Fuels and Lubricants"(2). This was prepared by the NavTechJap Petroleum Team with the assistance of C. O. Hawk, who was on loan to the mission by the U. S. Bureau of Mines, Coal Experiment Station, Pittsburgh.

Historical

Only two commercial-scale hydrogenation plants were installed in the Japanese Empire. Both now are in territory occupied by Russia. In 1936 the South Manchurian Railway Co. began construction at Fushun, Manchuria, of a unit having about 10,000 tons a year coal charge capacity, jointly designed by the Japanese Navy experts and the operator. In 1937 the Korean Nitrogen Fertilizer Co. started to build a plant at Agochi, Korea, twice the size of the Fushun plant. This, too, was based on the Navy process, but the reactor design was modified in accordance with the ammonia synthesis experience of the operating company.

Both plants were completed and began operations in 1939.

Apparently the Agochi plant never was able to achieve continuous operation on coal, due largely to excessive coking and plugging difficulties. Experiments were continued on the hydrogenation of low-temperature tar as well as coal until 1942, when the plant was converted to methanol synthesis.

The Fushun plant is reported to have been somewhat more successful, although many process changes were required. In July, 1942, it was completely converted to hydrocracking low temperature tar and petroleum oils for production of aviation gasoline components.

It appears no technical help to Japan was forthcoming from its Axis satellite, Germany. The Navy blocked a pre-war deal between the I. G. Farben and Ogura Oil Co. for licensing rights to the Bergius coal hydrogenation process, apparently on the basis that development of a satisfactory domestic process was imminent. Late in the war the Army resumed negotiations with the Nazis but apparently never received any actual aid.

Research on the Fischer-Tropsch synthesis was pioneered in Japan by Prof. G. Kita, at the Institute of Physical and Chemical Research, Kyoto Imperial University. His work started in 1927, one year after Franz Fischer's first published paper on the subject, and centered primarily on development of a cheap iron catalyst for use in both the "normal" (atmospheric) and "middle" pressure (150-225/psi syntheses.

The Imperial Fuel Research Institute at Kawaguchi also conducted research from 1933 to 1940, especially on nickel substitute catalysts, but

Co-Author

Clifton S. Goddin, Jr. received his M.S. in Chemical Engineering from the University of Michigan in 1937 and was in the Research Department of Standard Oil Co. (Indiana) until entering the Navy in 1941. His military service included two years as Navy Petroleum Officer in the Middle East and also duty in the Fuel Research Division of the Bureau of Ships and the Petroleum Team of the U. S. Naval Technical Mission to Japan. Since 1946 he has been in the Process Research Division of Stanolind Oil & Gas Co., Tulsa.

* C. S. Goddin, of Stanolind Oil & Gas Co., Tulsa, was a member of the Petroleum Team of the U. S. Naval Technical Mission to Japan.

** D. P. Thornton, Jr., is Assistant Editor of PETROLEUM PROCESSING.

made no significant developments. The Tokyo Imperial University studied substitute catalysts and developed a natural ore catalyst in 1943-44.

The Mitsui interests purchased rights to the Fischer-Tropsch synthesis from Ruhrchemie in 1936 and built a normal pressure cobalt catalyst unit at Miike, near Omuta, Kyushu, designed to produce 30,000 tons of crude product annually. This production never was closely approached, however, due to operational difficulties.

Mitsui, in cooperation with the Imperial Fuel Industries Co., built two more plants, a middle pressure unit at Takikawa, employing both cobalt and iron catalysts, and a normal pressure cobalt catalyst unit at Amagasaki. These interests also had two plants under construction in Manchuria at the end of the war.

The most successful method for production of oil from coal in Japan with respect to volume and cost of production was low temperature carbonization. Although studies of the process were started in 1921 by the Imperial Fuel Research Institute, difficulties in marketing the semi-coke by-product prevented any substantial peacetime development. This prompted the government to establish its "petroleum substitutes policy" in 1936 as a war measure, under which indemnities were provided for losses suffered in the production of such fuels. The coal carbonization industry expanded rapidly under this policy.

In 1938 came the Japanese Seven-Year Plan for synthetic oil development, establishing the Imperial Fuel Industries Co. (Teikoku Nenryo Kogyo K. K.). Under this plan, annual production of a million kiloliters (6,300,000 bbls.) each of synthetic gasoline and fuel oil was to be achieved by 1944. Teikoku Nenryo was authorized to finance synthetic oil enterprises and to manufacture and sell synthetic oils. At first, companies engaging in synthetic oil production were given subsidies based on oil output and were exempted from income, import and profit taxes. This was abolished in 1942 and the government thereafter purchased all synthetic oil at favorable fixed prices.

Synthetic oil production was to be achieved under the Seven-Year Plan by building 10 high-pressure coal hydrogenation units, each of 100,000 kl. per year oil output capacity; 66 low-temperature carbonization units each charging 100,000 metric tons of coal annually and 11 Fischer-Tropsch units each of 50,000 kl. capacity. The actual plants constructed in the Empire and their outputs during the war years are given in Table 1, based on data supplied by Teikoku Nenryo to occupation authorities.

The peak annual output of oil from all coal conversion processes amounted to only 114,000 kl. (717,000 bbls.) compared with the 2,000,000 kl. (12,-

TABLE 1—Location and Output of Japanese Synthetic Oil Plants

Company	Location	Design Capacity	Actual Fuel Output*-(kl) 1941	1942	1943	1944	1945
Coal Hydrogenation:							
1. Manchu Jinzo Sekiyu Co., Fushun Works	FUSHUN, Manchuria	2.5 T/hr Paste charge	....	770	....	690	....
2. Chosen Jinzo Sekiyu Co., Agochi Works	AGOCHI, Korea	5 T/hr Paste charge	....	....	....	....	....
Total Coal-Hydrogenation Oil			....	770	....	690	....
Fischer-Tropsch:							
1. Nippon Jinzo Sekiyu Co., Miike Works	OMUTA, Kyushu	37,500 kl./yr. Oil output	7,200	9,290	13,870	11,070	1,720
2. Nippon Jinzo Sekiyu Co., Amagasaki Works	AMAGASAKI, Honshu	37,500 kl./yr.	....	....	200	130	....
3. Nippon Jinzo Sekiyu Co., Takikawa Works	TAKIKAWA, Hokkaido	62,500 kl./yr.	....	1,550	1,600	6,610	2,480
4. Manchu Jinzo Sekiyu Co., Chielin Works	CHIELIN, Manchuria	1,000 kl./yr.		Under Construction			
5. Manchu Gosei Nenryo Co., Chinchu Works	CHINCHU, Manchuria	40,000 kl./yr.		Under Construction			
Total Fischer-Tropsch Oil		178,500 kl./yr.	7,200	10,840	15,670	17,810	4,200
Low Temperature Carbonization:							
1. Nissan Ekitai Nenryo Co., Wakamatsu Works	WAKAMATSU, Kyushu	4 Lurgi Units 4 x 300 T/day	8,760	9,620	16,850	21,570	6,550
2. Teikoku Nenryo Kogyo Co., Ube Works	UBE, Honshu	2 Koppers Units 4 Lurgi Units 6 x 300 T/day coal	....	10,400	19,250	18,390	4,840
3. Ube Kosan Co., Chisso Works	UBE, Honshu	2 Koppers Units 2 x 300 T/day coal	11,530	11,850	9,470	10,820	1,990
4. Toho Kagaku Kogyo Co., Nagoya Works	NAGOYA, Honshu	Tokyo Units	550	1,400	1,040	300	....
5. Nippon Yuka Kogyo Co., Kawasaki Works	KAWASAKI, Honshu	Knowles Ovens 30 x 7.5 T/day	320	2,170	4,700	....	....
6. Toho Kagaku Kogyo Co., Yokohama Works	YOKOHAMA, Honshu	Tokyo Units	310	790	430	....	....
7. Nippon Seitetsu Co., Wanishi Works	WANISHI, Hokkaido	Rotary-kiln 4 x 100 T/day	3,120	2,870	3,020	2,520	250
8. Nippon Jinzo Sekiyu Takikawa Works	TAKIKAWA, Hokkaido	Knowles Ovens 15 x 12 T/day		Under Construction			
9. Nippon Yuka Kogyo Co., Sorachi Works	SORACHI, Hokkaido	Knowles Ovens 120 x 12 T/day		Under Construction			
10. Teikoku Nenryo Kogyo Co., Naibuchi Works	NAIBUCHI, Sakhalin	Lurgi Units 2 x 300 T/day 2 x 200 T/day	....	....	3,560	16,770	8,330
11. Teikoku Nenryo Kogyo Co., Naihoro Works	NAIHORO, Sakhalin	Lurgi Units 4 x 200 T/day coal	14,000	15,330	17,920	12,140	2,950
12. Nippon Chisso Kogyo Co., Fian Works	EIAN, Korea	.....	....	4,620	3,760	930	....
13. Chosen Jinzo Sekiyu Co., Agochi Works	AGOCHI, Korea	Lurgi Units 6 x 150 T/day	6,260	6,090	10,470	11,920	240
14. Manshu Jinzo Sekiyu Co., Chielin Works	CHIELIN, Manchuria	Lurgi Units 4 x 150 T/day		Under Construction			
Total Low-Temperature Oil			44,850	65,140	90,470	95,360	25,150
Total, All Oil from Coal		2,000,000 kl.	52,050	76,750	106,140	113,860	29,350
Shale Oil (for comparison):							
Minami Manshu Tetsudo Co., Fushun Works	FUSHUN, Manchuria		137,780	163,280	160,140	83,150	16,530
Grand Total, Oil from Coal and Shale			189,830	240,030	266,280	197,010	45,880

Note—Oil output includes only gasoline, kerosene, diesel oil and fuel oil. It does not include such items as pitch, wax, lubricating oils, cresols, gas oil, etc.

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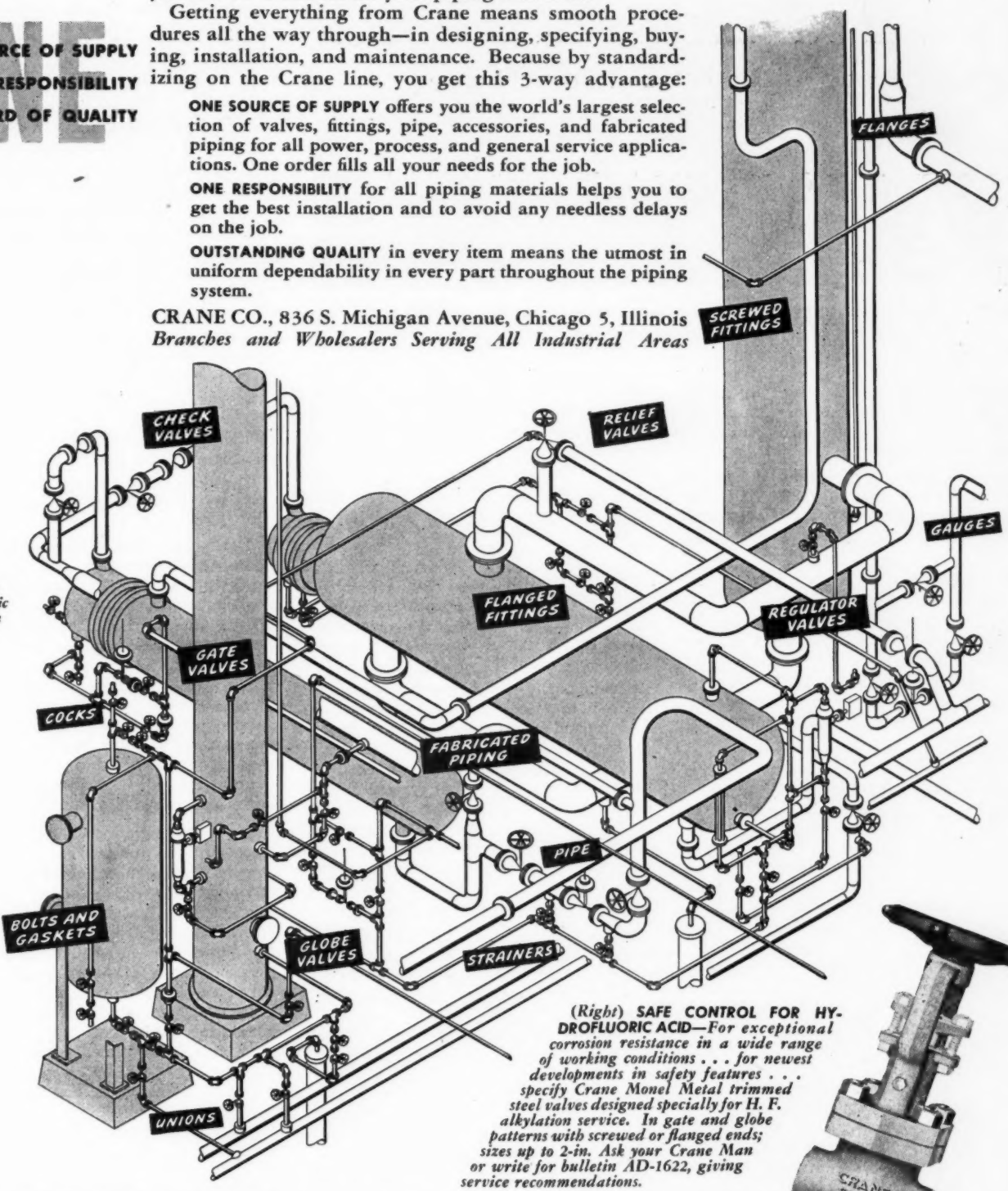
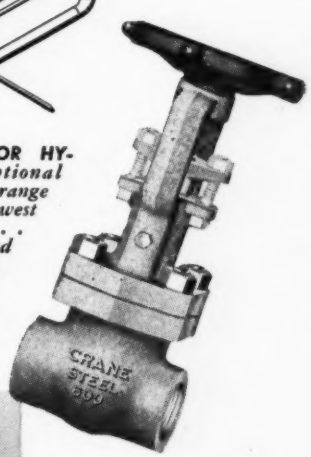


Piping to Hydrofluoric Alkylation Unit



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600,000 bbls.) of gasoline and fuel oil called for in the plan. This dismal performance resulted mainly from three causes:

1. The effect of the declaration of the European War in 1939 and the U. S. Moral Embargo which stopped shipment of equipment from this country.

2. Curtailment of the plant construction program in Japan after Pearl Harbor, due to diversion of critical materials for the most pressing military requirements.

3. Low outputs from both Fischer-Tropsch and coal hydrogenation plants actually built due to operating difficulties.

High Pressure Coal Hydrogenation Work of Japanese Navy

The Japanese Navy first started work on coal hydrogenation at Tokuyama in 1925, and occupied a key position in research to develop the process to commercial scale. The Navy's interest in this process came from its need to establish a dependable source of liquid fuels for its fleet.

The Tokuyama laboratory evaluated both Japanese and continental Asiatic coals for hydrogenation. In view of the direct cooperation between the Navy and the South Manchurian Railway Co., however, much of the Navy's laboratory work was concentrated on Fushun coal. Autoclave studies on reaction variables comprised the nucleus of the early work. The most important results of these experiments were:

1) Zinc chloride was found to be the most effective catalyst, although later a mixture of ferric oxide, sulfur and stannous hydroxide was chosen as the standard catalyst.

2) Reaction temperatures near 420° C. (788° F.) were found to be the highest practicable without encountering excessive coke and gas formation.

3) At pressures below 200 atmospheres (3000 psi.) excessive coke formation occurred and liquefaction was incomplete.

4) Vehicle viscosity was without effect on the hydrogenation reactions.

5) About one hour minimum contact time was required for complete liquefaction under the above conditions.

One of the most valuable contributions of the Tokuyama laboratory was an extensive survey of the properties of Chinese and Manchurian coals. General conclusions were that the coals of North China were more suitable for high-temperature coking than for hydrogenation whereas most coals of Manchuria hydrogenated readily. Similarly, those tested from Japan, Korea and Formosa also were deemed suitable for hydrogenation.

A semi-commercial coal hydrogenation plant, the first in Japan, was completed at Tokuyama about 1932. The unit comprised a single-converter liquid-phase system with a throughput of about 7 tons of paste (3 to 3½ tons of coal mixed with heavy recycle oil) per day. An electric hydrogen preheater was enclosed in the converter; otherwise the hydrogenation system was conventional.

Equipment for stripping volatile liquid hydrocarbons from the converter exit gases was provided in order that hydrogen recirculation could be effected. Process hydrogen was furnished by electrolysis of water at a maximum rate of 200 cu. m. per hour. Heavy oil containing the ash and unliquefied constituents of the coal was withdrawn through a manually controlled valve, with attempts to maintain continuous discharge proving troublesome. Solids were separated from the heavy oil by centrifuging.

No written records were available for semi-commercial operation between 1932 and 1938, but plant personnel estimated the unit was on-stream only about a third of the time. Typical data obtained in 1938-1939 during a five-day run on Oyama coal from Fushun are summarized in Table 2. Difficulties were experienced in the separation of solids from heavy oil by centrifuging, and in the non-uniform distribution of hydrogen and paste in the reactor.

Erosion of the heavy oil discharge mechanism was severe and the lack of flow control instrumentation made it difficult to maintain uniform operating conditions. Results of the tests on this coal are of particular interest because of their relationship to the full scale operation at the South Manchurian Railway Co. plant at Fushun. Oyama coal is described as "a very high quality brown coal approaching bituminous."

Imperial Fuel Research Institute Work

Both laboratory and semi-plant scale hydrogenation of coal was studied by the Imperial Fuel Research Institute from about 1931 to 1940. The purpose was to carry to full demonstration scale a process for liquefaction of Japanese coals, and work was done without direct cooperation with the Navy or any industrial group. Over 100 coals were hydrogenated in small autoclave tests, the results of which show in general that practically all Japanese coals are suitable for hydrogenation.

Three of the more suitable coals were further studied in a pilot plant having a charge capacity of 3-5 tons of paste (1½ to 2½ tons of coal) per day. This plant possessed a double converter liquid-phase reaction system, and had simplified design features. These were intended to insure maximum operability, permitting study of engineering problems connected with economical operation of a full-scale plant. Its operation,

TABLE 2—Results of Hydrogenation of Oyama Coal

Catalyst....$ZnCl_2$ (amount used not specified)	
Operating temperature	415° C
Average pressure	200 kg/cm²
Fresh hydrogen input	185 m³/hr (N.T.P.)
Rate of hydrogen recirculation	1,000 m³/hr (N.T.P.)
Paste input	282 kg/hr
Ratio (vehicle/coal)	3/2
H_2 consumption—(wt.-% of coal)	7.97
Wt.-% of coal liquefied	77.9
Yield of oil, wt.-% of total oil:	
Oil boiling below 180° C.	3
Middle oil, boiling 180-280° C.	40
Heavy oil, boiling above 280° C.	53

although reported to be reasonably successful, contributed little to the development of commercial hydrogenation in Japan.

Industrial Scale Coal Hydrogenation

The construction of the South Manchurian Railway Co. plant at Fushun, Manchuria, was undertaken in 1936 after some 10 years of cooperative experimentation by the Naval Research Laboratory at Tokuyama and the S.M.R. Central Research Laboratory at Dairen. The Navy stipulated that all machinery and process equipment must be made in Japan and pressure vessels were to be fabricated at the Kure Navy Yard. The converters were 7.3 meters long by 95 cm. I. D. and were the largest vessels of this type which could be made in Japan at the time.

The converters originally proposed by the Navy were to be provided with propeller-type stirring devices, but the S.M.R. technical staff foresaw a serious leakage problem with every type of packing gland suggested. In consequence, the converter actually installed had no stirring apparatus and was made by bolting together two of the 7.3 meter sections.

The Navy also proposed the use of a zinc chloride catalyst to the extent of 1% by weight of the coal. S.M.R. objected to this catalyst, both on the basis of cost and attendant corrosion difficulties, and it finally was agreed to use a precipitated iron sulfide catalyst found to be effective at the same concentration employed for the zinc. It is stated that no form of iron oxide was found to be as effective as ferrous sulfide.

Preliminary operation of the Fushun plant began in 1939, utilizing a single converter. A second converter was added in the same year. Nominal design coal charge capacity was 10,000 metric tons per year, corresponding to a paste input of 4 tons per hour. The Oyama coal averaged about 42% volatile matter with 10-12% ash. It was ground to 4 mesh, partially de-ashed, and mixed with catalyst and heavy recycle oil in a tube mill mixer. Ratio of vehicle to coal was about 1.5 by weight. Hydrogenation conditions were 200 atmospheres and 430° C. (806° F.).

Liquid phase coal hydrogenation was continued until 1940, when a separate vapor phase reaction system was installed at the Navy's direction. From then until July, 1942, the plant operating schedule was divided between liquid phase coal hydrogenation and vapor phase hydrogenation of fractions from low temperature tar and the liquid phase coal process. From July, 1942 until the end of the war, coal hydrogenation was completely abandoned and full attention was given to manufacture of aviation gasoline by hydrocracking of gas oil and kerosine.

The plant as modified for vapor phase operation was designed to process about 40 kl. of oil per day at 200 atmospheres pressure over a fixed catalyst consisting of 40% molybdenum sulfide and 60% acid clay. Two reactors were used in series, operating at 430-440° C. The yield of gasoline obtained by combined liquid and vapor phase operation was about 35% by weight of coal charged. About 50% of the gasoline was of aviation grade.

The approximate total oil output of the Fushun plant from 1939 to the end of the war was estimated at 15,000 tons, most of which was heavy oil from liquid phase hydrogenation of coal. The low total production, realized in spite of the severe stress of Japan's need for oil during the war, is considered direct evidence that substantial difficulties were encountered in plant operation.

Information secured by the NavTechJap Petroleum Team on the second commercial coal hydrogenation plant at Agochi, Korea, was meager. It was installed about the same time as the Fushun plant and the design capacity was about 20,000 tons of coal per year. The plant apparently did not successfully function as a coal hydrogenation unit, due to severe overheating and excessive coking in the reaction zone. In 1942 the plant was abruptly modified to produce synthetic methanol. In general, it was apparent that Japan, in her acute need for oil, had plunged into industrial coal hydrogenation without acquiring an adequate background of pilot plant scale experience. Commercial operations also were hindered by lack of alloy steels and facilities for manufacturing reaction vessels of proper size.

Fischer-Tropsch Synthesis

Research at Kyoto University

According to the NavTechJap reports, the most important research on the Fischer-Tropsch synthesis done in Japan was that of Prof. G. Kita and associates at Kyoto University. Much of the following information resulted from interviews with these men.

Kita's work began from a purely scientific viewpoint and at first was primarily concerned with testing various types of catalysts and operating variables in small-scale glass apparatus at normal pressure (atmospheric). They were not able to develop a catalyst superior to the conventional German cobalt-thorium mixture, although it was claimed that a nickel catalyst with activity equal to that of cobalt-thorium was obtained in the laboratory.

After rights to prepare and use the German cobalt catalyst had been purchased by the Mitsui interests, work at Kyoto was concentrated on the development of a cheap iron catalyst as a substitute for cobalt in normal pressure synthesis. It was found that boric acid was an effective

View of the low temperature tar distillation unit at the coal carbonization plant at Ube. These columns were camouflaged with bamboo which was scattered by the bombing. Plant also was flooded when bombing wrecked the harbor dykes

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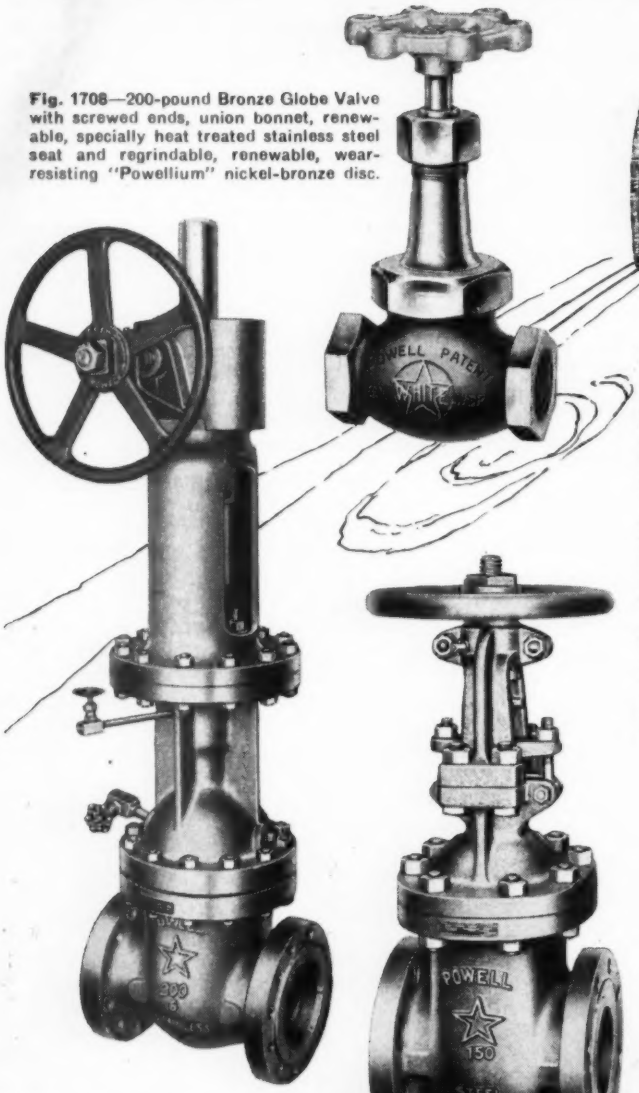

Fig. 1708—200-pound Bronze Globe Valve with screwed ends, union bonnet, renewable, specially heat treated stainless steel seat and regrindable, renewable, wear-resisting "Powellium" nickel-bronze disc.

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Fig. 3003 S. S. Mod.—Class 300-pound Cast Alloy Steel Gate Valve. Designed to withstand the ultra high temperatures encountered in T. C. C. Has drain valves in stuffing box and bonnet and cooling fins to dissipate the heat thereby reducing the temperature in the stuffing box. Gear operated.

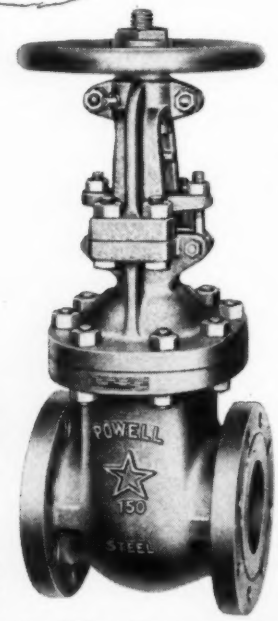

Fig. 1503—Class 150-pound Cast Steel Gate Valve with flanged ends, bolted flanged yoke, outside screw rising stem and taper wedge solid disc.

Fig. 241—Large 125-pound Iron Body Bronze Mounted Globe Valve. Made in sizes 2" to 16", incl. Has outside screw rising stem, bolted flanged yoke and regrindable, renewable bronze seat and disc. Also available in All Iron.

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TABLE 3—Laboratory Comparison of Catalysts for Normal Pressure Synthesis

Composition of Catalysts (Parts by weight)	Composition of Raw-gas. ($CO:H_2$) (2)	Gas Flow L/hr	Reaction Temp. (° C)	Oil Yield (cc/m³) Kerosine	Gasoline	Total	Life of Catalysts
Co-15 Mn-150 Kieselguhr	1:2	4	200	72.5	72	144.5	more than one month
Co-18 ThO_2-150 Kieselguhr	1:2	4	190	100	53	153	about two months
Co-5 Cu-12 U_3O_8 4 Mn-100 KSG	1:2	6	195	...	...	158.2	.....
Co-7 Cu-5 ThO_2-2.5 U_3O_8-125 KSG	1:2	4	200	97	54	151	.....
							22nd day
Fe-25 Cu-2 Mn-1.25 Kieselguhr-2 K_2CO_3	1:2	4	230	52	22	74	27 cc/m³
							17th day
	1:2	4	240	43	36	79	42 cc/m³
							18th day
	1:2	4	230	62	33	95	17 cc/m³
Fe-25 Cu-2 Mn-125 Kieselguhr-15 H_3BO_3-3 K_2CO_3	1:2	4	240	59	39	98	about one month
							22nd day
	1:2	4	250	44	49	93	48 cc/m³
Fe-25 Cu-2 Mn-125 Kieselguhr-20 H_3BO_3-4 K_2CO_3	1:2	4	240	66	36	102	about one month
Ochre-1 Cu-4 K_2CO_3	1:2	4	240	45	29	74	.....
							30th day
Ochre-1 Cu-5 K_2CO_3	1:2	4	240	40	33	73	39 cc/m³
Ochre-5 Cu-4 K_2CO_3	1:2	4	240	44	35	79	.....
							30th day
Ochre-1 Cu-1 H_3BO_3-6 K_2CO_3	1:2	4	240	52	34	86	62 cc/m³
							30th day
Ochre-1 Cu-5 H_3BO_3-8 K_2CO_3	1:2	4	240	51	35	86	57 cc/m³

All % signs deleted.

additive for iron catalysts and the most effective normal pressure catalyst developed had the following composition (parts by weight):

$$100Fe + 25Cu + 2Mn + 125Kieselguhr + 15H_3BO_3 + 3K_2CO_3$$

Experiments showed that boric acid promoted the adsorption of active hydrogen, whereas alkali promoted adsorption of carbon monoxide. The product from a high alkali catalyst also was less saturated than from a high acid catalyst. The effects were almost independent, so that when boric acid was added to a catalyst, alkali also would be added to increase the adsorption of carbon monoxide. It was found that for synthesis at middle pressure (150 to 225 psi) the use of boric acid actually was harmful, apparently due to over-adsorption of hydrogen as result of the higher partial pressure.

After Prof. Matsubara (Tokyo University) discovered the natural iron catalyst in 1943-44; Kyoto University undertook tests at both normal and middle pressures. The catalyst utilized was a natural yellow earth (ochre) having the typical analysis:

Moisture	6.4%
Ignition Loss	20.7
Fe_2O_3	64.8
Undetermined	8.1
	100.0%

X-ray diffraction analysis of this material indicated the crystal form to be $Fe_2O_3 \cdot H_2O$. The ore also probably contained some SiO_2 and $CaCO_3$. The best natural earth normal pressure catalyst tested at Kyoto had the following composition (by weight):

$$100Ochre + 1Cu + 1H_3BO_3 + 6K_2CO_3$$

A comparison of several of the more promising normal pressure catalysts is given in Table 3. In the case of the Kyoto laboratory, the tests were made in small laboratory glass apparatus containing 40 cc. of catalyst. Gasoline was absorbed on silica gel or by a dry-ice condenser, and kerosine was the product from a water condenser.

Table 3 shows that the best natural catalyst gave a yield of 86 g. per cu. m., which was lower than results on the best synthetic iron catalyst, 98-102 g. per cu. m., and in turn was lower than results on the best cobalt catalyst, 151-158 g. per cu. m. At normal pressure the synthesis reactions were stated to be as follows for iron and cobalt catalysts:

Catalyst	Reaction
Iron	$2\,CO + H_2 \rightarrow :CH_2 + CO_2$
Cobalt	$CO + 2\,H_2 \rightarrow :CH_2 + H_2O$

In the case of iron catalysts, however, when gas with a $CO:H_2$ ratio of 2:1 was used, catalyst life was very short due to carbon poisoning of the surface. When gas with higher hydrogen content was used the life was longer, but yields were lower than with cobalt catalyst.

During 1937-41 studies were also made in a semi-commercial pilot plant at Kyoto with a charge capacity of 100 cu. m. per hour of water gas. This plant was transferred in 1942 to the new Army Fuel Research Institute at Fuchu for use in testing of natural iron catalysts. The normal presure catalyst, 100 parts by weight of $Fe + 25Cu + 2Mn + 125Kieselguhr + 20H_2BO_3 + 4K_2CO_3$, also was tested in a full scale reactor at the Miike Synthetic Oil Co. Results were not satisfactory since only 225° C. reaction chamber temperature could be reached whereas the minimum for this catalyst was 235° C.

Increasing the reaction pressure greatly favors the iron catalyst and from 1939 on work at Kyoto was concentrated on the study of various iron catalysts and suitable operating conditions for the middle pressure synthesis. All work at middle pressure was done in small, single-tube apparatus containing about 40 cc. of catalyst, and with synthesis gas charge capacity of about 4 liters per hour. Pilot plant tests were made in a small 10 cu. m. per hour unit constructed at the Takikawa Fischer-Tropsch plant. A full-scale reactor was installed there in 1943 to test iron catalysts and it was planned to install 15 additional reactors.

In Table 4 laboratory data are summarized comparing various middle pressure catalysts. A catalyst of the composition by weight of $100Fe + 25Cu + 125Kieselguhr + 4\text{-}6K_2CO_3$ was manufactured in a 200-liter-per-day catalyst manufacturing plant for tests at Takikawa. Later it was found that the addition of magnesium increased oil yields, and the best middle pressure catalyst developed

TABLE 4—Comparison of Catalysts for Middle Pressure Synthesis, Laboratory Tests at Kyoto Imperial University

	Composition of Catalysts (Parts by weight)	Gas Comp. $CO:H_2$	Gas Flow over 40 cc cat L/hr	Press Kg/cm²	Temp. ° C	Yield inc. wax. g/m³
Cobalt	Co + 8 MgO + 5 ThO + 200 Kieselguhr.... (from Miike Synthetic Oil Plant)	1:2	4	10	185	143
					190	
Iron	Fe + 25 Cu + 125 Kies + 4 K_2CO_3.....	1:1	4	10	190	41
					200	67
					210	83
					220	101
					230	105
					240	115
					250	106
	Fe + 25 Cu + 125 Kies + 6 K_2CO_3.....	1:1	4	15	210	120
	Fe + 25 Cu + 5 Mg + 125 Kies + 6 K_2CO_3	1:1	4	10	210	111
				15	190	70
Natural	Ochre + 0.5 Cu + 5 Mn + 6 K_2CO_3	1:1	4	10	210	74
					230	99
					250	112

All % signs deleted.

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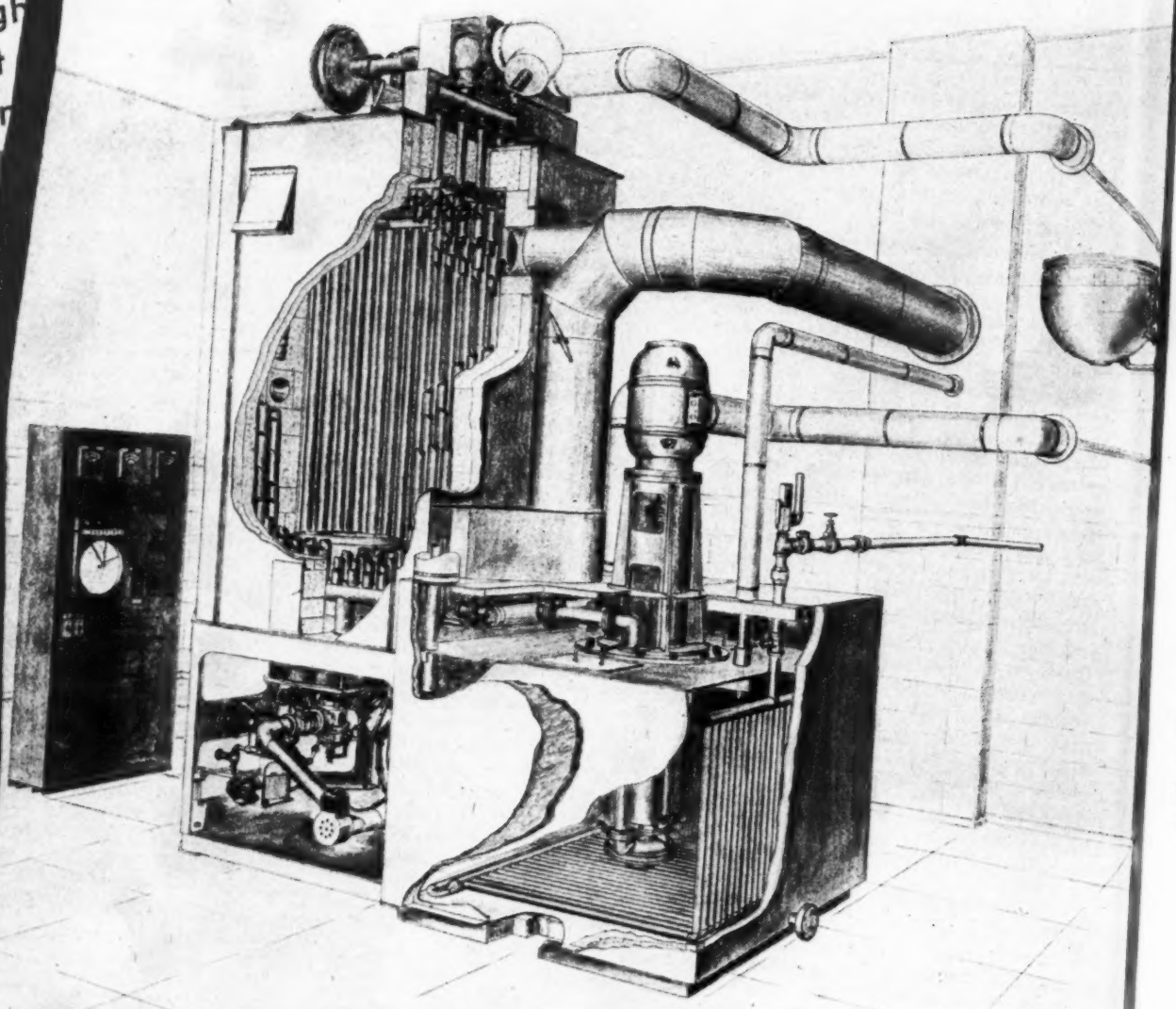

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had the composition of 100 parts Fe + 25Cu + 5Mg + 125Kieselguhr + $6K_2CO_3$. Test data on this catalyst also are given in Table 4.

The Japanese believed that, under operating conditions of 15 atm. pressure, 220-240° C. and synthesis gas with H_2:CO ratio of 1:1, yields equal to those of cobalt would be obtained. Further, a catalyst life of six months could be expected, compared with two months for cobalt, under commercial scale operation. The only natural iron catalyst tested at middle presure at Kyoto is listed in Table 4. This same catalyst was manufactured by the Japanese Army at Fuchu for full scale tests at Takikawa.

In connection with the use of iron catalysts, it was found necessary to remove all forms of sulphur, although their sensitivity was lower than that of cobalt at normal pressure and even less at middle pressure. Halogens also were definitely poisonous to this catalyst. Such gases as oxygen, carbon dioxide and nitrogen were not harmful.

Considerable work was done during 1938-45 on the application of the Fischer-Tropsch principle for production of C_3 and C_4 compounds, to develop a source of light hydrocarbons for synthesis of iso-octane. It was stated that a process had been developed on laboratory scale where, by using an iron catalyst at 15 atm., 275-280° C. and with a CO:H_2 ratio of 1:1, about 44% of the synthesis gas could be converted into light hydrocarbons containing 50% propane and 20% butanes.

Other Research

The Japanese Navy did little research on the Fischer-Tropsch synthesis, primarily because this process was not a suitable source of heavy fuel oils. Experimental work on both laboratory and semi - commercial plant scale was carried on at the Imperial Fuel Research Institute, with the intention of developing a complete full-scale process, but was abandoned in 1940 when the Miike plant began operation. Because of the high cost and difficulty of obtaining cobalt, studies on the substitution of nickel were intensively conducted. Yields above 100 grams total liquid product per cubic meter of synthesis gas were obtained in laboratory tests, but the life of the best catalysts apparently was limited to about a month. In a semi-commercial plant, only a few days activity could be obtained. Iron catalysts were not investigated.

Commercial Fischer-Tropsch Plants

Only five Fischer-Tropsch units were built in the Japanese Empire, and of these only three were put on stream, namely the plants at Miike, Amagasaki and Takikawa. The two other plants, still under construction at the end of the war, were located in Manchuria.

The Miike synthetic oil plant, located in Kyushu, was the first plant constructed, and utilized the atmospheric pressure synthesis under Ruhrchemie's license to the Mitsui interests. This unit was inspected by the NavTechJap Petroleum Team and was found to be similar in all respects to plants constructed in Germany. The plant included some 56 water-cooled Ruhrchemie reactors, each containing 4.5 tons of cobalt-thorium catalyst. The synthesis was effected at 180-200° C. using a synthesis gas having a hydrogen-to-carbon monoxide ratio of 2:1 obtained by blending water gas with reformed coke oven gas. Actual throughput of gas was 750 cu. m. per hour per reactor. Actual yield of oil was 70-85 g. per cu. m., compared with an expected yield of 116.

The plant produced liquid propane and butanes, motor gasoline (40 CFR-M octane number), Diesel fuel (90 Cetane) and several grades of paraffin wax. Design capacity was 30,000 metric tons of crude products per year but actual production during the peak year, 1943, was only 16,000 tons. Low production was due primarily to less than design production of synthesis gas (due to generator difficulties caused by low melting ash in Miike coal), and low activity of Japanese manufactured catalysts. Even at the reduced production rate, however, the plant was Japan's most successful Fischer-Tropsch unit as is shown by the production figures of Table 1. The plant was put out of production by bombing in August, 1945.

The Takikawa plant, in Hokkaido, was designed to operate at middle pressure (about 150 psig.) utilizing cobalt catalyst and reactors of both Ruhrchemie and Japanese designs. Tests were carried on with the precipitated iron catalyst developed by Prof. Kita and the natural iron catalyst of Prof. Matsubara. Both installations at Amagasaki and Takikawa, as shown by Table 1, failed to produce in accordance with design figures.

Coal Carbonization

The Imperial Fuel Research Institute, beginning in 1921, played a leading part in the endeavor to establish a self-sufficient low temperature carbonization industry in Japan. It conducted laboratory and pilot plant assays of the carbonization characteristics of a large number of Japanese coals and particular attention was devoted to development of market outlets for the semi-coke, representing some 65% by weight of the coal charged.

Since the end of the war, the Institute has concentrated on developing the use of the semi-coke as a domestic fuel, and in particular, that obtained from brown coal. The semi-coke from brown coal has satisfactory ignition and combustion properties. It can be produced at about one half the cost of the charcoal so widely used in Japan for domestic cooking and heating purposes. However, all samples as yet prepared burn with a slight, but objectionable odor which has prevented ready public acceptance.

Both the Japanese Army and Navy conducted but little research on carbonization processes. Neither achieved results of commercial significance.

Industrial Coal Carbonization

Industrial low temperature coal carbonization did not comprise an important part of Japan's pre-war economy. The tar produced could not carry the cost of the process and, as explained above, no dependable market was found for the semi-coke. Accordingly, government subsidies were instituted to stimulate growth of the industry as a war measure.

It was planned to produce motor gasoline and fuel oils from the tar by simple distillation and aviation gasoline by hydrocracking suitable middle and heavy oil fractions. Although the hydrocracking program materialized only to a limited extent, the manufacture of liquid fuels by simple distillation of low-temperature tar made a far greater contribution to Japan's war production than high-pressure coal hydrogenation and the Fischer-Tropsch synthesis combined (Table 1).

From information obtained by NavTechJap investigators, it appears that growth of the coal carbonization industry in Japan began about 1934 with the building of two Koppers units at the Chisso plant, Ube. A total of at least 11 plants were put into operation throughout the Japanese Empire, and three more were under construction at the end of the war.

German-developed low temperature carbonization units, especially the Lurgi type, are preferred in Japan. No Japanese-developed carbonization system has proven successful. The Tokyo Gas Co. type plants installed at the Nagoya and Yokohama works were the only instances found of the commercial use of Japanese-designed equipment.

The retort of the Tokyo system comprised a horizontal rotating steel drum, externally heated and provided with an internal scraping device to prevent accumulation of partially carbonized coal on the walls. Ex-

Avgas Manufacture in Japan

Third article in the group based on the reports of the Petroleum Team of the U. S. Naval Technical Mission to Japan will cover the Japs' manufacture of aviation gasoline. This included catalytic cracking and desperate efforts to synthesize the product from many available raw materials.

A first article, in the November Petroleum Processing, discussed the Japs' program to obtain sufficient petroleum supplies to carry on the war, both natural and synthetic products.

cessive damage from overheating was suffered by both vessel and scraper, resulting in abandonment of these plants about 1943. The coal charge to these plants possessed some caking properties, undoubtedly contributing to the operating difficulties experienced.

The plants at Ube, Kawasaki, Wakamatsu, Agochi and Nagoya originally were built to supply tar for hydrocracking. Gasoline manufacture by this method never was realized commercially to any significant extent, however, and the liquid fuel production figures for the five plants (Table 1) represent processing of low-temperature tar by conventional distillation.

A typical low-temperature carbonization installation was inspected by the petroleum team at Wakamatsu, Kyushu. This plant was based on the Lurgi patents and German engineers assisted in the construction and acceptance tests of the first units. The plant was completed in 1941 and production of gasoline, fuel oil and semi-coke began immediately. It proved to be one of Japan's most important producers of liquid fuels from coal. Its carbonization and refining facilities were expanded and steady production was maintained until the installation was disabled by a fire-bomb raid in August, 1945.

Japanese personnel interviewed at Wakamatsu said that the tar yield actually attained was about 10 wt.-% of the coal, corresponding to 90% of the figure predicted by the Fischer-Hempel assay test. The coal charged was a non-caking or weakly-caking bituminous variety obtained from the nearby Orio district. Few operating difficulties were encountered, although the actual retort throughput varied somewhat with the actual coal charged.

The Teimen plant at Ube also was an important liquid fuel producer during the war, as indicated by the production figures of Table 1. Projected annual output capacity of this plant was 40,000 kl. of gasoline, to be obtained from Ube brown coal by combining low-temperature carbonization with hydrocracking of the light tar oil. Synthetic ammonia and methanol also were to be manufactured.

Construction of the plant began in 1941. The hydrocracking plant, never completed, was designed on the basis of the Navy's research at the First Naval Fuel Depot. Two Koppers carbonization units, each with a throughput capacity of 300 metric tons of coal daily, were completed in February, 1942, and maintained production until severely damaged in bombing raids of July and August, 1942. Of ten 300-ton per day Lurgi retorts originally planned, four were completed and in operation and the remaining six under construction when the bombing occurred.

The Future

The Nipponese obviously are not particularly happy over their adventures with either the Fischer-Tropsch synthesis or hydrogenation of coal. Hydrogenation seems particularly destined to remain dormant because the Russians long since have placed Japan's two commercial plants, in Manchuria and Korea respectively behind the customary "Iron Curtain."

The Miike Fischer-Tropsch plant, since it suffered relatively little bomb damage, undoubtedly will be used in the future. However, it is doubtful if new plants will be built unless Nippon is permitted to use the American "fluid" technique in handling the catalyst, and even this has yet to be proven successful in the two commercial "Synthol" or "Hydrocol" plants now being built in the U. S.

One thing is certain, however. Domestic production of crude oil in the Japanese Empire is inadequate even for present domestic peacetime needs. Her shale oil supplies are entirely cut off and will remain so as long as Russia continues to occupy Manchuria or unless other deposits are discovered in the present Empire. Consequently, either crude petroleum or refined products must be imported—as now is the case—or else the deficit must be made up by synthetic oil production.

It appears that the Nipponese "white hope" will continue to be low-temperature coal carbonization. Alone, this process produced more synthetic oil than all other syntheses combined and undoubtedly has the best chance of receiving permission from Occupation authorities for future operation and expansion. Moreover, many of these plants received little difficultly-repairable bomb damage.

The only stumbling block to economic operation of this process seems to be a market for the by-product coke, because of its objectionable odor. It seems logical that the general scarcity of charcoal in Japan today may assist in overcoming this objection, especially if the historic practice of using unvented "habachis," instead of stoves, is abandoned.

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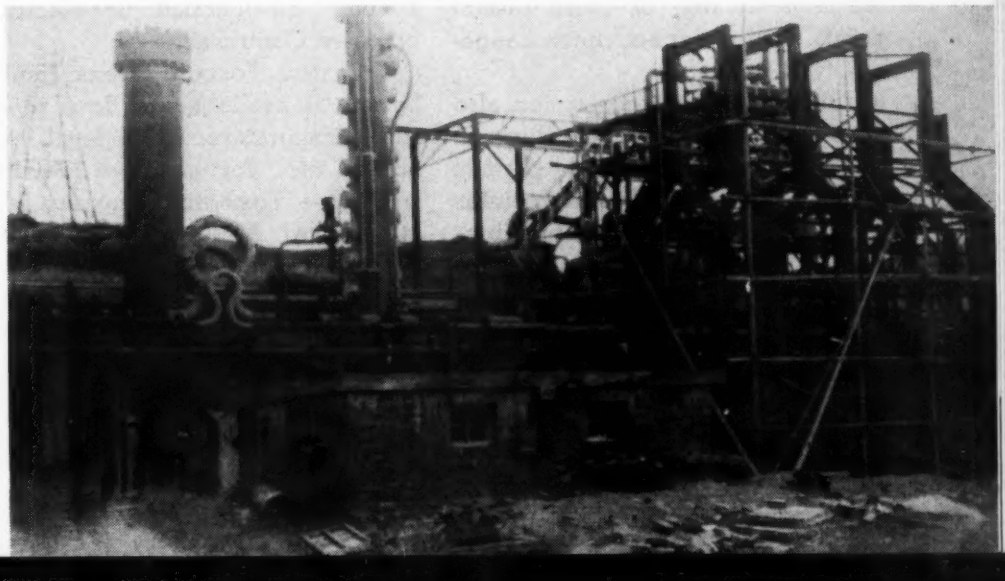
(1) Thornton, D. P., Jr., "Desperate Japs Tried to Make 'Avgas' Even from Pine Tree Roots, Needles," PETROLEUM PROCESSING 2, No. 11, pp. 815-20 (1947).

(2) U. S. Naval Technical Mission to Japan, Petroleum Team (assisted by C. O. Hawks, U. S. Bureau of Mines Coal Experiment Station, Pittsburgh), Report No. 7, Index No. X-38(N)-7 "Japanese Fuels and Lubricants, Progress in the Synthesis of Liquid Fuels from Coal."

Universal Oil Products Co., thermal cracking unit under construction at the Miiki Fischer-Tropsch plant. It was intended for cracking synthetic fuel oil to gasoline.



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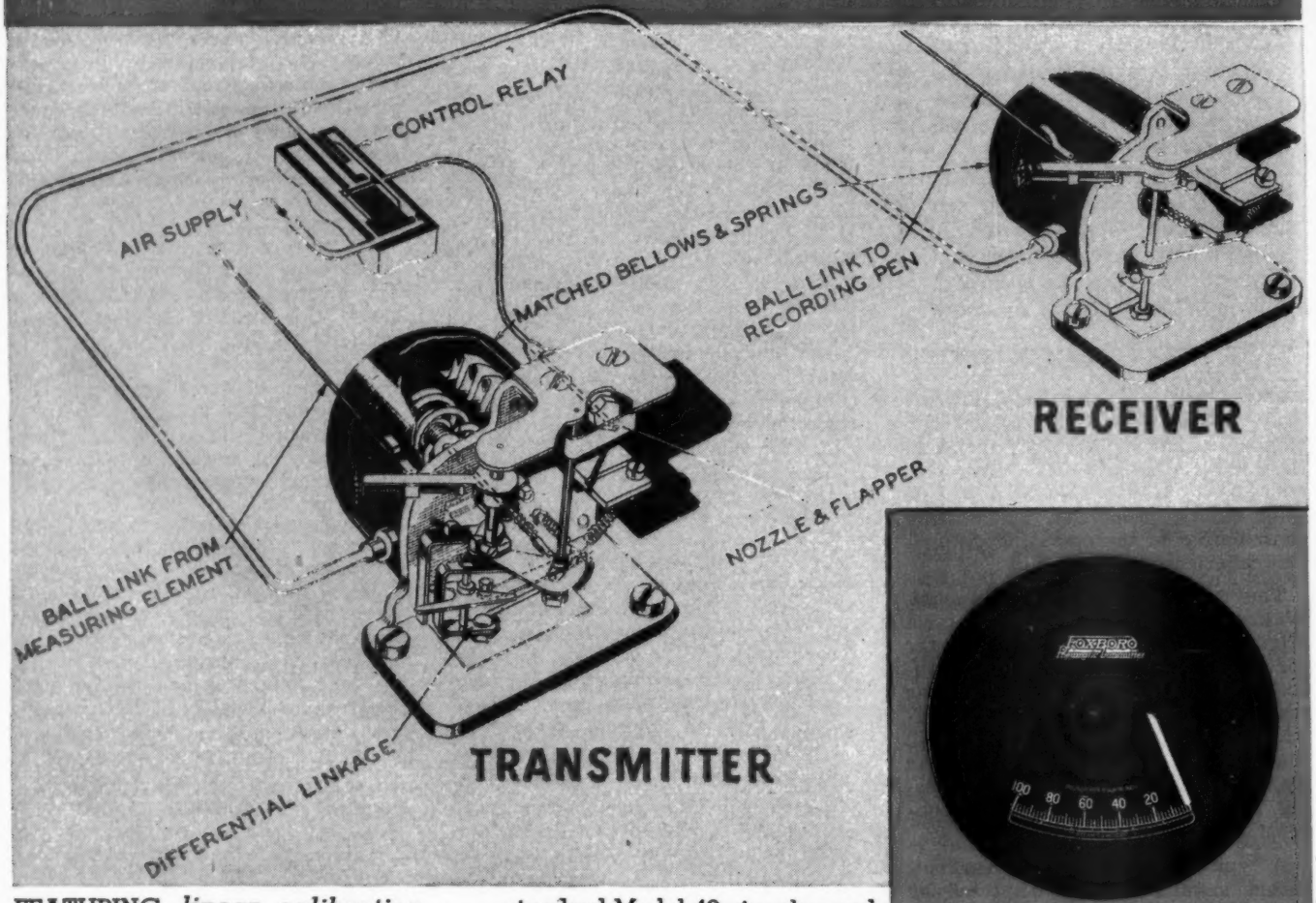

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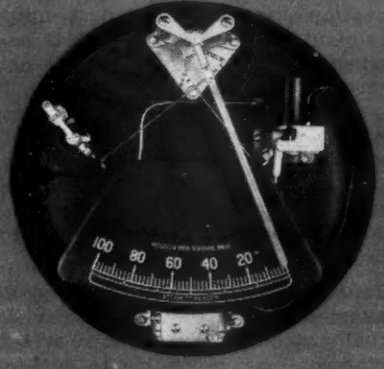

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Catalytic Desulfurization and Reforming Of Naphthas Over Bauxite

By C. J. HELMERS and G. M. BROONER
Phillips Petroleum Co., Research Dept.

Catalytic desulfurization of both straight-run and cracked naphthas offers a means of improving the clear and leaded octane rating. Even though sulfur content of a cracked gasoline is relatively low, it may be desirable to treat it over bauxite at normal desulfurizing conditions since a part of the octane improvement of cracked stocks appears to be due to olefin isomerization.

Catalytic desulfurization of high sulfur naphtha prior to thermal reforming produces a low sulfur reformed gasoline and results in higher yields of gasoline when reforming to a given leaded octane level.

Catalytic reforming of naphtha over bauxite differs from catalytic desulfurization in that a higher temperature level is required, some gaseous products are produced and the unleaded octane rating is improved from 5 to 15 octane numbers, depending upon the nature of the feed stock and the severity of treatment.

PRIOR to the war, the desirability of upgrading any individual component going into a final motor fuel blend was principally a matter of economics and involved, primarily, savings in tetraethyl lead additions. Desulfurization was therefore largely restricted to high-sulfur, straight-run stocks to improve lead susceptibility.

The general upward trend in motor fuel octane values the past several months, somewhat accelerated by the existence of wartime processes such as catalytic cracking, has raised many refining problems and injected new factors into the consideration of upgrading motor fuel components. Many such components, both straight-run and cracked, are now below the octane level necessary to meet competition even with the addition of maximum quantities of tetraethyl lead. It is therefore of prime necessity to the refiner not only to increase the lead susceptibility of all component streams of the final motor fuel blend but also to raise the unleaded octane values.

The various sulfur compounds found in hydrocarbon stocks are the principal cause of decreased lead susceptibility[1] and desulfurization in some manner has been the primary means of increasing lead susceptibility. Several methods of desulfurization have been described and practiced. These include such familiar processes as hydrogenation, sulfuric acid treatment, caustic washing processes either with or without various additives to increase the solubility of mercaptans and vapor phase catalytic treatment. This discussion will be restricted to the latter process employing bauxite as a catalyst.

Catalytic Desulfurization

This process, commonly known as the Perco Catalytic Desulfurization process, is illustrated in the flow diagram in Fig. 1. The process consists essentially in vaporizing and superheating the hydrocarbon feed, after which the superheated vapors are passed over the bauxite catalyst where the sulfur compounds are decomposed. The product from the catalyst chambers is cooled and condensed and processed for removal of the hydrogen sulfide resulting from decomposition of the sulfur compounds. For a more detailed description of the operation the process reference is made to previous publications[2, 3, 4]. The temperature of treatment may vary from 650° F. upward, depending on the nature of the stock and the desired results. Operating pressures from 25 to 200 psi. have been utilized in commercial operations. Little, if any, effect on the degree of desulfurization has been noted within this pressure range. The principal reaction involved in the catalytic desulfurization process is the decomposition of the sulfur compounds into hydrogen sulfide and the corresponding olefin.

The bauxite catalyst will adsorb appreciable quantities of hydrogen sulfide at the temperature of operation. This is evidenced by the absence of hydrogen sulfide in the cata-

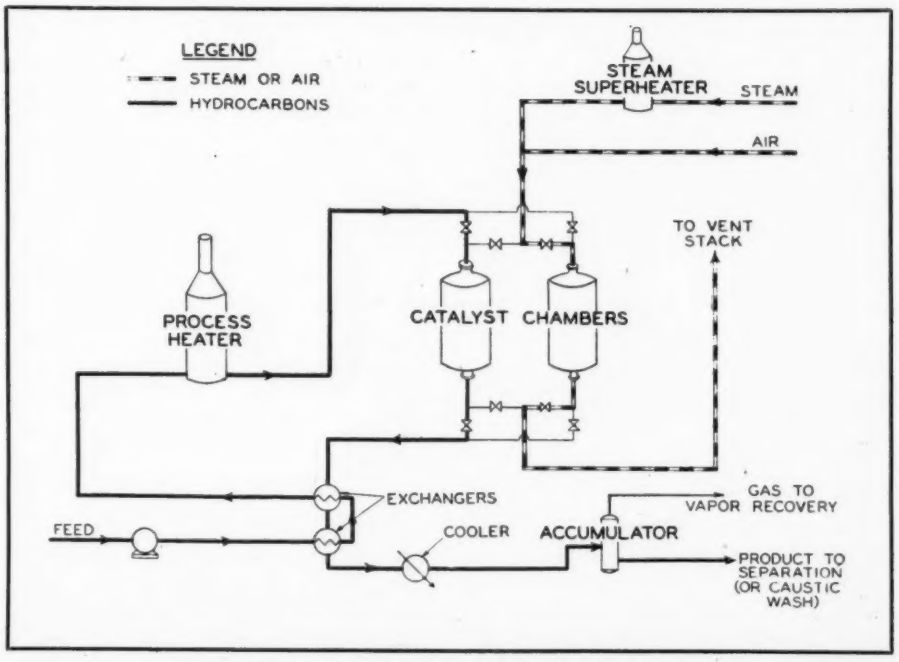

Fig. 1—Perco catalytic desulfurization—reforming

lyst chamber effluent for several hours after the initiation of a test using new or regenerated catalyst. This adsorption of hydrogen sulfide does not appear to have any effect on the catalytic activity of the bauxite as far as desulfurization is concerned and equilibrium is soon reached between adsorption and desorption of hydrogen sulfide. The adsorbed hydrogen sulfide is burned off during regeneration and appears as sulfur dioxide in the waste combustion gases.

Of the types of sulfur compounds found in hydrocarbon stocks the most common are mercaptans, alkyl sulfides and disulfides, aryl sulfides, thiophenes, and thiophanes. Of these types all but thiophenes are more or less readily decomposed by bauxite under the usual conditions of temperature and pressure. Thiophenes appear essentially unaffected by the process. The sulfur compounds found in higher boiling stocks are more difficult to remove and, as the boiling range of the charge is increased, the per cent of sulfur removed decreases. For stocks boiling in the range of 500-600° F. the total sulfur removal may range downward to the order of 30%, while for lighter hydrocarbons the removal may exceed 95%.

Straight-Run Gasoline

The processing of straight-run gasoline offers the simplest application of the bauxite desulfurization process. Compounds such as thiophanes and thiophenes are seldom found in these stocks and total sulfur reductions of 85% or better are usually obtained. There is little or no effect on the physical properties of the gasoline, such as boiling point, gravity and volatility. No appreciable evolution of gas other than hydrogen sulfide occurs and the yield of treated product is normally 98% or better. Carbon deposition which results in loss of catalytic activity is both slow and gradual, and long operating cycles are obtained.

Throughputs of 5,000-15,000 bbl. per ton of catalyst are obtained without regeneration for stocks of 375-400° F. end point. With a throughput of 5000 bbls. of gasoline per ton of catalyst, the catalyst cost amounts to about one ct. per bbl. of gasoline; consequently, the catalyst may either be discarded or regenerated as economics dictate. As the boiling range of the stock is increased above 400° F. the rate of carbon deposition increases, resulting in decreased catalyst life without regeneration. Carbon deposition from heavy stocks may be lessened to some extent by employing higher space velocities, however, for the average stock having an end point above 500° F. the throughput per ton is decreased to a point where catalyst regeneration is usually mandatory.

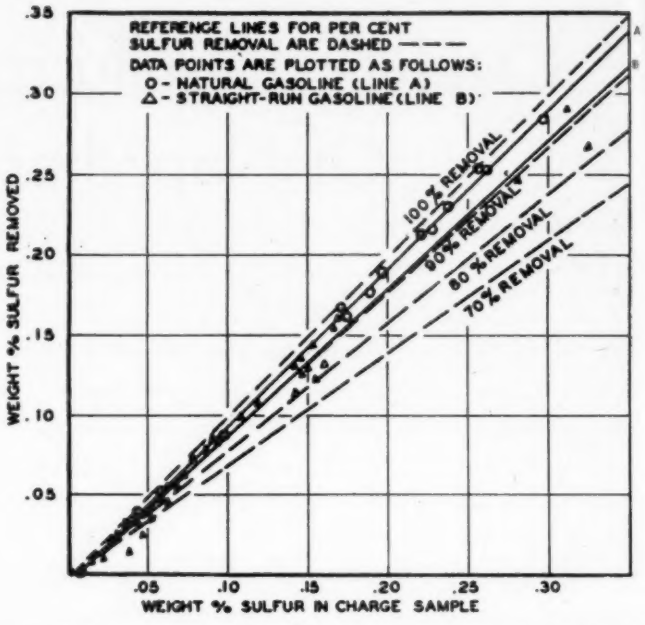

Fig. 2—Sulfur removal from natural gasoline and straight-run gasoline

Data illustrating typical results which were obtained on four straight-run gasolines, ranging from very low to high sulfur content, are shown in Table 1. Sample A has been included to show that when processing straight-run stocks the octane improvement is from sulfur removal only. This sample containing only 0.0022% total sulfur was desulfurized at normal conditions. Inspection tests on the charge and product are within the reproducibility of the test methods. Samples B, C and D, containing progressively higher sulfur contents, also show progressively increasing octane improvements from desulfurization. It will be noted that the percent sulfur removal is of the same order regardless of the sulfur content of the feed. This is characteristic of straight-run gasoline stocks and is more clearly shown in Fig. 2. This curve shows the per cent sulfur removal on a considerable number of tests on natural and straight-run gasolines. The reference lines for constant sulfur removal show that most stocks fall in the range of 85-95%.

Cracked Gasolines

The desulfurization of olefinic or cracked gasolines differs from the processing of straight-run gasolines in several respects. From an operating standpoint the principal difference is in the requirements of catalyst regeneration. In desulfurizing cracked gasoline the rate of carbon deposition on the catalyst is much more rapid than is the case with paraffinic stocks. As a result operating cycles of the order of 500 bbls. of gasoline per ton of bauxite are normally employed. Economics usually preclude discarding the catalyst and regeneration facilities are required. Referring to Fig. 1, catalyst regeneration facilities are shown in conjunction with processing equipment. The regeneration operation consists in passing a superheated air-stream mixture over the catalyst which burns off the corbonaceous deposits. The air-stream mixture is superheated to a temperature of about 750° F. and the temperature within the burning zone is controlled in the range of 1200-1400° F. by regulating the ratio of air to steam. Repeated regeneration does not appear to affect the activity of the bauxite and catalyst in use has been regenerated over 1000 times without appreciable loss in activity.

The results obtained from the desulfurization of cracked gasolines differ markedly from those on straight-run gasolines especially in the degree of sulfur removal. As mentioned previously, thiophenes are not appreciably affected and, since these com-

TABLE 1—Catalytic Desulfurization of Straight-Run Gasolines

Sample	A		B		C		D	
Crude Source	Rodessa		Panhandle		West Texas		West Texas	
	Charge	Product	Charge	Product	Charge	Product	Charge	Product
ASTM Octane Number	56.8	56.8	58.7	59.9	53.2	56.7	53.8	57.8
Plus 1.0 ml TEL	70.2	70.4	68.0	72.2	61.4	68.4	59.2	68.9
Plus 3.0 ml TEL	80.2	80.4	77.0	80.1	69.9	78.2	65.9	77.4
Total Sulfur, Wt. %	0.0022	0.0008	0.028	0.003	0.116	0.008	0.309	0.017
Gravity, °API	67.5	67.6	67.1	67.1	56.7	56.8	58.4	57.8
Reid Vapor Pressure	7.5	7.4	9.6	9.3	5.3	5.7	6.0	5.6
ASTM Distillation, °F								
First Drop	104	102	93	98	106	106	110	118
5%	134	135	129	127	147	149	140	152
10%	148	148	147	142	172	174	157	167
50%	199	198	205	203	262	264	240	241
90%	255	256	271	261	354	354	334	331
95%	271	273	320	291	371	374	360	356
End Point	324	320	320	316	394	410	398	402

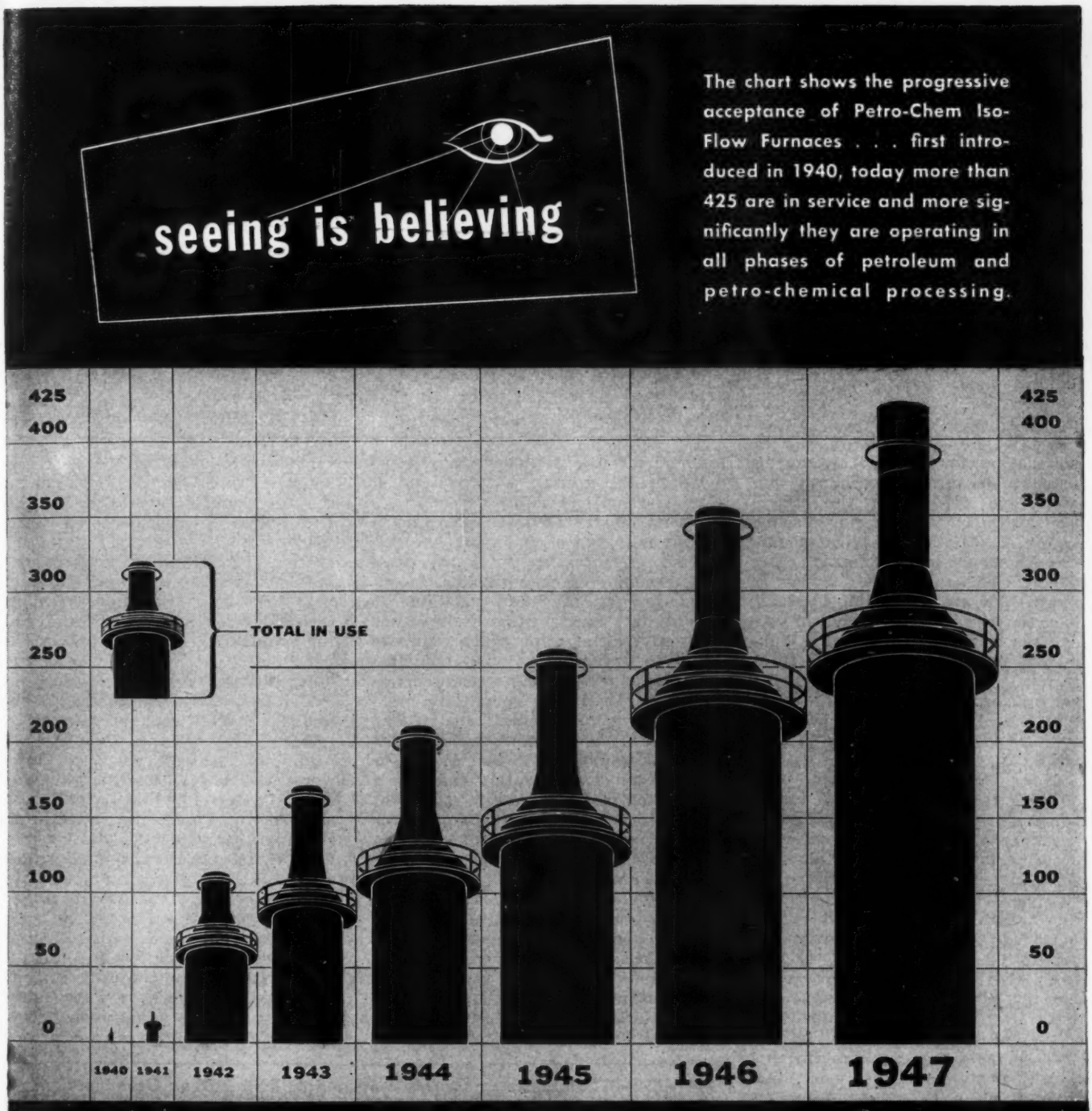

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TABLE 2—Catalytic Desulfurization of Cracked Gasolines

Sample	E		F	
Crude Source	Oklahoma City		West Texas	
	Charge	Product	Charge	Product
ASTM Octane Number	58.5	63.3	67.8	71.4
Plus 1.0 ml TEL	67.7	72.3	72.9	76.6
Plus 3.0 ml TEL	74.9	78.0	76.6	79.5
Research Octane Number	64.0	69.5	76.2	79.3
Plus 1.0 ml TEL	72.8	78.4	81.9	85.7
Plus 3.0 ml TEL	80.8	84.6	87.0	90.1
Total Sulfur, Wt. %	0.017	0.014	0.235	0.162
Mercaptan Sulfur, Wt. %	....	....	0.028	0.008
Gravity, °API	51.5	51.0	56.4	56.3
Reid Vapor Pressure	4.3	4.7	7.7	8.1
ASTM Distillation, °F.				
First Drop	121	114	98	95
5%	170	167	126	120
10%	198	194	143	140
50%	301	299	264	265
90%	366	392	364	367
95%	400	409	380	389
End Point	416	474	403	450

TABLE 3—West Texas Cracked Gasoline; Catalytic Desulfurization vs. End Point Reduction

			Undesulfurized Rerun Cuts		
	Charge	Desulf.	A	B	C
ASTM Octane Number	51.1	60.8	56.9	59.2	61.2
Plus 1.0 ml. TEL	57.1	66.3	62.8	64.8	65.8
Plus 3.0 ml. TEL	64.2	72.0	68.7	70.4	70.9
Total Sulfur, Wt. %	0.289	0.154	0.281	0.283	0.273
Gravity, °API	56.5	56.5	59.0	60.0	61.2
Reid Vapor Pressure	3.0	3.6	3.1	3.5	3.8
ASTM Distillation, °F.					
First Drop	129	131	129	125	128
5%	175	173	168	161	161
10%	194	195	184	179	179
20%	224	223	207	202	200
50%	285	283	268	256	243
70%	319	320	301	285	268
90%	360	362	337	317	296
95%	379	396	347	327	308
End Point	404	455	364	352	332
Recovery, %	99.0	98.8	99.0	99.0	99.0
Residue, %	0.6	0.7	0.5	0.4	0.2
Loss, %	0.4	0.5	0.5	0.6	0.8
Yield, Vol. % on 400 F. End Point Gasoline	100.0		86.6	77.6	67.1

pounds are found in widely varying amounts in cracked gasolines, such stocks do not exhibit the correlation shown by straight-run gasolines in Fig. 2. Of the sulfur compounds, thiophenes are minor offenders in reducing lead susceptibility. Sulfur removal from cracked gasolines usually is of the order of 40-50%, but in some cases may be as low as 30%. It is due in part to the lower degree of sulfur removal and in part to the inherent poor susceptibility of olefinic stocks that the octane improvement is not so marked in desulfurizing cracked gasolines.

Octane improvements of the order of three to five numbers are usually obtained from desulfurizing cracked gasolines, however, much greater improvements have been obtained in some instances. Unlike straight-run gasolines, this improvement is usually shown both in the unleaded as well as leaded ratings and, depending upon the sulfur content of the original stock, the lead susceptibility may or may not be improved. The net result is therefore a general upward shifting of the entire lead curve.

These facts are important in that they indicate that reactions other than desulfurization are occurring. It is probable that the principal other reaction is isomerization either in the form of chain branching or shifting of the olefinic bond. For this reason consideration of desulfurizing cracked gasolines should not be restricted to high sulfur stocks since substantial improvement may be obtained regardless of sulfur content. The physical properties of the stock are not appreciably affected although there is some increase in end point due to polymerization. Yield of desulfurized product is 95% or better.

Data on the desulfurization of a low-sulfur and a high-sulfur cracked gasoline are given in Table 2. A comparison of the octane increases for these two examples clearly shows the lack of correlation between octane improvement and sulfur reduction. The clear octane increase obtained for sample E is somewhat above the average, but is not unusual and illustrates the results which may be achieved on low sulfur stocks.

That the catalytic desulfurization process is one of the most effective means of increasing the octane value of thermally cracked gasolines is emphasized by the data in Table 3. These data compare the results of undercutting end point against bauxite desulfurization. End point reduction as a means of meeting octane requirements is becoming more and more common in the refining industry. The data in Table 3 show that for this stock a larger octane increase is obtained by desulfurization than by a reduction of 75 degrees in end point and a resultant loss of 33% of product. A value differential of only 0.5c per gal. between the heavy naphtha discard and the low end point motor fuel would be required to compare this operation economically against the operating costs of catalytic desulfurization.

In many instances, especially in small refineries, it is not always practical to operate the desulfurization unit on individual streams. Considerable work has therefore been done on processing blends of straight-run and cracked stocks. Catalyst life and octane improvement are about what would be predicted from desulfurization of the stocks separately with subsequent blending of the products. The data in Table 4 show typical results obtained from desulfurizing three samples of straight-run gasoline blends.

Thermal Reforming Stocks

The desulfurization of straight-run naphtha stocks prior to thermal reforming has been investigated. The first data available on this subject were published within the past few months[4] and additional tests have since been completed. The thermal reforming operation in itself usually gives a sulfur reduction of the order of 60%. The sulfur remaining, however, is in very stable forms, principally thiophenes, and is not easily removed by catalytic desulfurization or other feasible means. Catalytic desulfurization of the paraffinic reformer charge produces a very low-sulfur reformed gasoline. This reduction in final sulfur content gives an improved

TABLE 4—Catalytic Desulfurization of Straight-Run Cracked Gasoline Blends

Sample	G		H		I	
Crude Source	Kansas		Pennsylvania		Turner Valley	
	Charge	Product	Charge	Product	Charge	Product
ASTM Octane Number	59.1	62.5	64.4	66.5	64.2	68.0
Plus 1.0 ml TEL	69.0	72.8	73.6	77.4	71.6	78.0
Plus 3.0 ml TEL	76.3	80.1	79.8	83.2	77.5	82.8
Research Octane Number	61.7	63.4	66.0	68.2	71.3	72.3
Plus 1.0 ml TEL	71.0	73.4	76.2	79.4	77.3	82.0
Plus 3.0 ml TEL	80.0	82.4	83.6	86.5	83.9	88.2
Total Sulfur, Wt. %	0.052	0.026	0.041	0.007	0.059	0.019
Gravity, °API	63.0	62.7	65.9	65.4	60.8	60.3
Reid Vapor Pressure	7.6	7.3	9.8	9.4	10.4	10.1
ASTM Distillation, °F.						
First Drop	100	98	90	95	93	90
5%	130	129	113	114	105	108
10%	149	147	129	132	123	130
50%	231	230	216	218	222	235
90%	324	318	300	300	315	324
95%	353	351	325	327	336	346
End Point	392	414	363	390	357	396

TABLE 5—Effect of Catalytic Desulfurization on Yield of Thermally Reformed Gasoline

Sample	Thermally Reformed Gasolines			
	J		K	
	Undesulf. Charge	Desulf. Charge	Undesulf. Charge	Desulf. Charge
Yield of 75 ASTM Octane Butane Free—400 E.P. Gasoline				
Vol. % with 1.0 ml TEL	67.5	70.7	69.0	71.4
Vol. % with 3.0 ml TEL	73.9	81.0	77.8	80.4
Total Sulfur, Wt. %	0.175	0.035	0.046	0.015

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TABLE 6—Catalytic Reforming of Straight-Run Naphtha

Sample	L		M	
	Charge	Product	Charge	Product
Yield Summary				
Dry Gas, Wt. %	.....	7.78	.....	5.21
C_3 Total, Vol. %	.....	3.10	.....	3.24
C_4 Olefin, Vol. %	.....	2.88	.....	2.37
C_5 and Heavier Gasoline, Vol. %	100.0	88.40	100.0	90.54
Carbon, Wt. %	.....	0.65	.....	0.37
Inspection—C_5 and Heavier Gasoline				
ASTM Octane Number	41.8	55.6	42.4	60.8
Plus 1.0 ml TEL	53.5	65.2	53.0	68.6
Plus 3.0 ml TEL	64.8	74.1	59.8	75.3
Research Octane Number	43.2	57.0	40.3	64.4
Plus 1.0 ml TEL	52.6	67.3	48.7	71.8
Plus 3.0 ml TEL	67.4	77.2	57.9	80.7
Total Sulfur, Wt. %	0.015	0.012	0.200	0.037
Reid Vapor Pressure	4.8	1.8	0.7	1.3
Gravity, °API	54.9	52.0	49.0	48.4
ASTM Distillation				
First Drop	139	150	245	176
5%	185	199	267	230
10%	233	217	275	252
50%	306	297	314	302
90%	364	362	370	364
95%	378	379	387	382
End Point	425	428	422	432

TABLE 7—Catalytic Reforming Cracked Naphtha

Sample	N	
	Charge	Product
Yield Summary		
Dry Gas, Wt. %	.....	4.32
C_3 Total, Vol. %	.....	3.08
C_4 Olefin, Vol. %	.....	2.22
C_5 and Heavier Gasoline, Vol. %	100.0	90.94
Carbon, Wt. %	.....	0.79
Inspection—C_5 and Heavier Gasoline		
ASTM Octane Number	61.1	65.8
Plus 1.0 ml TEL	67.4	72.0
Plus 3.0 ml TEL	72.5	76.2
Research Octane Number	65.8	73.7
Plus 1.0 ml TEL	73.2	79.8
Plus 3.0 ml TEL	80.2	84.6
Total Sulfur, Wt. %	0.112	0.111
Reid Vapor Pressure	0.6	2.5
Gravity, °API	48.2	47.4
ASTM Distillation, °F.		
First Drop	222	145
5%	239	201
10%	248	223
50%	298	290
90%	375	366
95%	397	415
End Point	420	452

octane-yield relationship for the reformed desulfurized charge as compared to the undesulfurized charge, the amount of the improvement depending on the sulfur content of the original naphtha.

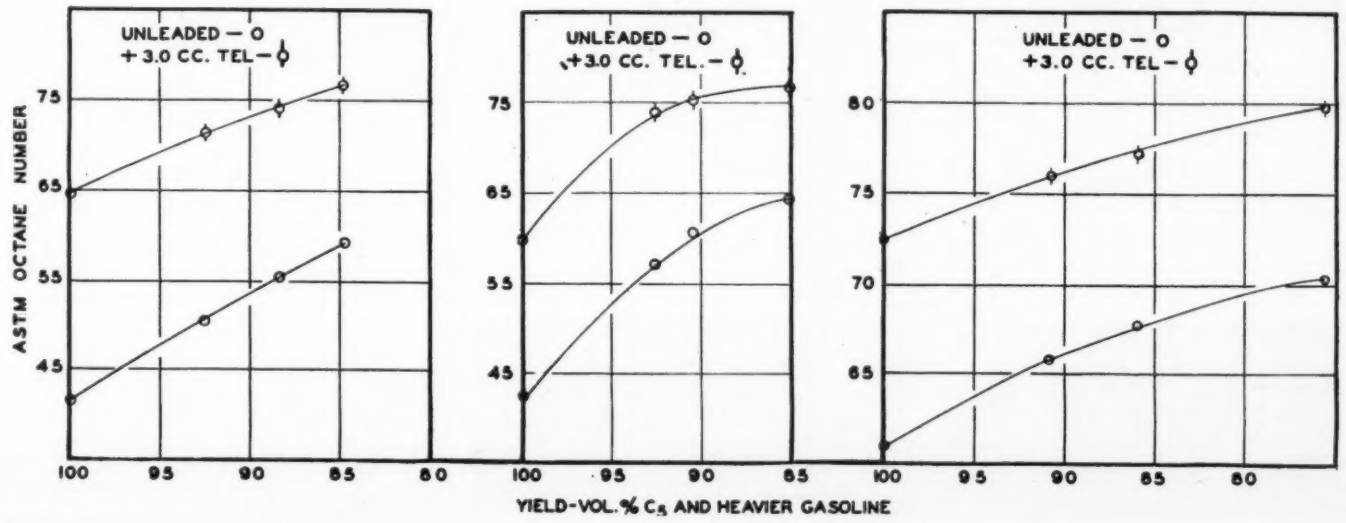
The results of two series of tests are shown in Table 5 in which sample J had a total sulfur content of 0.941 wt. % and sample K a sulfur content of 0.113 wt. %. These data show that when reforming to 75 ASTM octane with 1.0 and with 3.0 ml TEL the yield from naphtha J may be increased by 3.2% and 7.1%, respectively, through desulfurization of the reformer charge. Similarly for Sample K the yield is increased 2.4% with 1.0 ml TEL and 2.6% with 3.0 ml TEL.

Sample J is an unusual stock in that the sulfur content is far above that encountered in what are usually considered high-sulfur stocks. It emphasizes, however, the results which may be realized by reducing the final sulfur content of thermally reformed gasolines. Sample K is more illustrative of results which are obtained on average stocks. This typical straight-run naphtha gave a smaller but significant improvement in the octane-yield relationship for the desulfurized charge.

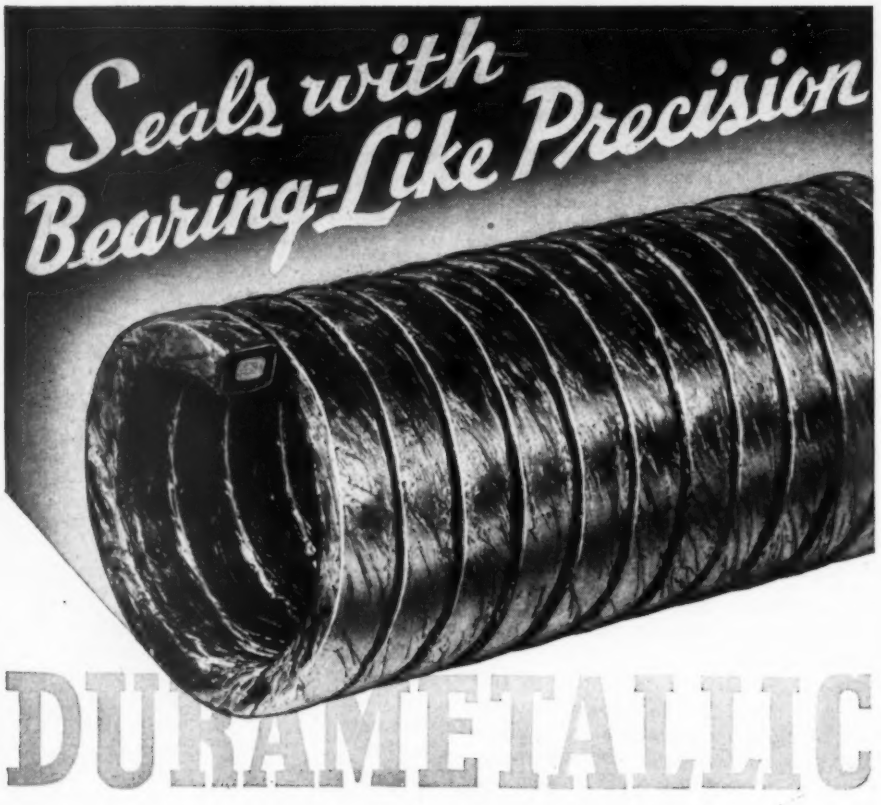
One unusual fact developed in this series of tests is the apparent property of sulfur compounds to promote fixed gas production in the reforming coil. Four reforming tests were made at various destruction levels on each comparative set of reformer feed stocks, both raw and desulfurized. In each instance the four comparable pairs of reforming tests were made at identical conditions of temperature, pressure and time-temperature relationship and in every case the undesulfurized charge gave a lower gasoline yield and higher fixed gas production than the desulfurized charge.

Catalytic Reforming

The Perco catalytic reforming process is similar to the catalytic desulfurization process except for temperature of processing. Processing periods of 18 to 36 hours are usually employed in this catalytic process. The process and regeneration operations are as described previously and shown in Fig. 1. The temperature of operation, however, is of the order of 950-1050° F., exact conditions depending on the degree of reforming desired and the refractoriness of the stock. At these temperatures the bauxite acts as a cracking or reforming catalyst as well as a desulfurization catalyst. The advantage of the catalytic reforming process, therefore, is that the benefits derived from a reduction in sulfur content are obtained coincident with an appreciable increase in octane level resulting from reforming. The reforming process produces some fixed gases and carbon, and the gasoline yield is correspondingly reduced depending on the degree of reforming. The clear octane rating of the reformed product normally is increased in the order of 10-20 octane numbers over the charge depending on the original octane rating, severity of reforming and sulfur content of the charge. The lead susceptibility is somewhat reduced but not to the



Figs. 3, 4, 5—Octane-yield relationships for catalytic reforming various naphthas: Fig. 3 (left), sample L, low sulfur, straight-run naphtha; Fig. 4 (center), sample M, high sulfur, straight-run naphtha; Fig. 5 (right), cracked naphtha



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degree occasioned in thermal reforming.

While catalytic desulfurization is obtained simultaneously with the catalytic reforming, it has been observed that the degree of sulfur removal is usually slightly less than that obtained at normal catalytic desulfurization temperatures. The volatility and also the end point of the reformed product are increased to some extent as compared to the charge. The increase in end point is sufficient to require rerunning to meet specifications but the amount of polymer formation is usually of the order of one or two %. No heavy residuum or tars as encountered in thermal reforming are produced.

The catalytic reforming process is applicable to either straight-run or cracked stocks or blends of the two. Table 6 shows data obtained in one test each on a low sulfur and a high sulfur straight-run stock. Fig. 3 and 4 show the yield octane curve obtained in a series of tests on each of these stocks. These data are typical of the octane improvements obtained on straight-run naphthas of these types. Table 7 gives the results of a test on a cracked naphtha and Fig. 5 shows the octane-yield curve obtained on the complete series of tests on this stock. Considerable data on blends have been given in previous papers and will not be further discussed here.(4, 5) The results on blends, however, are of the order of those obtained on the above stocks.

The economic values of the above processes are evident in view of today's octane requirements and especially when considering future motor fuel octane values of 79 and 84 ASTM as predicted for 1950 by A. P. Frame in a review of this matter before the Division of Refining of the American Petroleum Institute in St. Louis.(6)

Acknowledgement

Presented before the Mid-West Section of the American Chemical Society, Kansas City, June 23-25, 1947.

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Boiler Plant Furnace Designed To Burn By-Product Fuels

PRESENT costs of standard fuels such as coal, oil and gas have focused attention on the burning of by-products from refinery operations for steam generation, Otto de Lorenzi, director of education for Combustion Engineering Co., brought out in a paper presented at the annual meeting of the American Society of Mechanical Engineers, Atlantic City, Dec. 1-5.

The value of such substitute fuels depends largely upon the use of suitable furnace designs, it was stated. A steam generating unit installed in an eastern refinery was described, as shown in Fig. 1. It is designed for a continuous capacity of 125,000 lb. of steam per hour at 800 psi. and 750° F., with initial operation at 450 psi.

Fuels used are Bunker C oil, refinery gas, soda tar, and acid sludge, with provision for future pulverized-coal firing. Four horizontal, turbulent-type burners, are arranged to handle any of the fuels. The units are frequently operated on three of these fuels simultaneously. The most frequently used combination is oil, soda tar and refinery gas.

The units have regenerative-type air heaters. The furnaces are water-cooled and designed for a continuous heat-liberation rate of 25,000 Btu per hour with oil at a corresponding efficiency of 84.3%. With soda tar efficiency is 85.6% and with acid sludge 84.8%.

Typical analyses for refinery by-product fuels bunker C oil, acid sludge and refinery gas are presented in Table 1.

The following discussion of refinery by-product fuels was given by Mr. de Lorenzi in his A.S.M.E. paper entitled, "Furnaces for By-Product Fuels:

"By-products from oil-refinery operations consist of a wide variety of refuse fuels. There are solids, such as asphaltic pitch and petroleum coke. The liquids or sludges are often of high specific gravity and contain variable amounts of solid matter in suspension. Refinery gas, blended refinery gas, yard gas, and still gas are names applied to some of the gaseous by-products.

"**Asphaltic Pitch.** When the distillation of oil is stopped somewhat early, there remains a residue which is solid at room temperature but fluid at still temperature. This residue is asphaltic pitch, with a melting point of about 125° F., and it is usually pumped direct from process to burner at a temperature of 300 to 600° F. Under these temperature conditions it is a fluid which is readily atomized, and can be burned without difficulty. Its properties are somewhat similar to the heavier grades of bunker C oil and therefore furnace-design limitations are practically the same.

"**Petroleum Coke.** Petroleum coke is the solid residue remaining after cracking or carrying the distillation of crude oil sufficiently far. Its characteristics depend upon the process used. Volatile-matter content varies from 4 to 12%, and the sulfur and ash also vary widely. Ash-fusion temperature may be as low as 2000° F. Grindability ranges from that of extremely hard and abrasive coke, similar to metallurgical coke, down to one that can be easily pulverized with low power consumption and low mill maintenance. This pulverized fuel is readily burned in water-cooled furnaces, provided moderate heat-liberation rates, between 15,000 and 22,000 Btu per cu. ft. per hour, are used.

"**Acid Sludge.** The characteristics of a sludge are governed by those of the crude oil used and the manner in which it is processed. Much of the suspended solids may be carbonaceous, in the form of small particles of petroleum coke. Continuous agitation and recirculation at velocities high enough to prevent settling out are necessary to avoid plugging of fuel lines.

"Perhaps the most widely available and yet most troublesome, because of its frequently varying characteristics, is acid sludge. Its gravity may range between 5 and 14 API and its viscosity is indeterminate. It contains varying quantities of weak sulfuric acid which may reach as high as 40% and this, together with the suspended carbonaceous material and flux, which must be added in variable amounts to make the sludge flow, causes the heating value to vary between 8000 and 17,500 Btu per lb.

"Due to the suspended solid matter, it is necessary to use relatively large orifices in the atomizer. As a result, atomization is coarse and ignition is not always stable. Refinery practice is to burn the sludge as a supplementary fuel to gas or oil. Each steam-generating unit is provided with several combination-type burners, some of which operate, with gas or oil, to maintain ignition and reasonable capacity during periods when sludge supply is of erratic quality.

"The products of combustion, resulting from acid-sludge burning, carry a large quantity of water vapor. Gas temperature, at the outlet of heat-recovery equipment, must be well above the dew point if moisture deposit and resulting corrosion of the metallic surface is to be avoided. Maximum furnace - liberation rate should not exceed 25,000 to 30,000 Btu per cu. ft. per hour.

"**Refinery Gas.** The heating value of refinery gas is higher than that of natural gas, owing to the larger percentage of heavier hydrocarbons

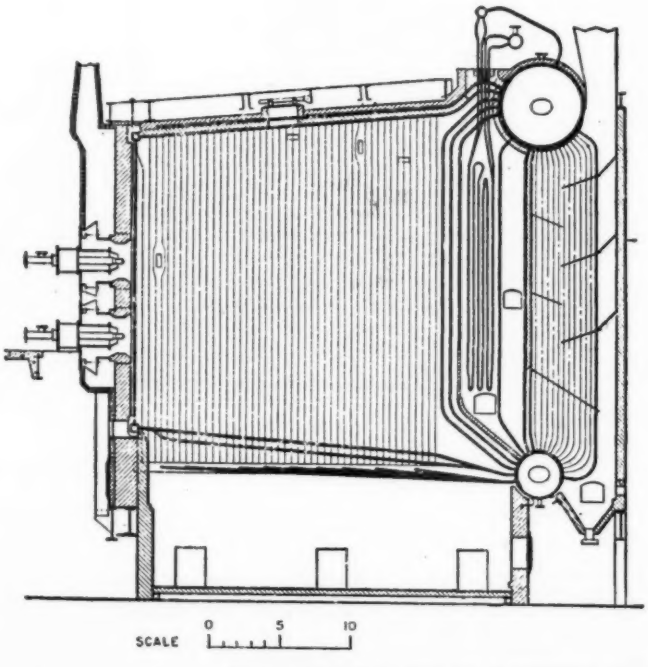

Fig. 1—One of several steam-generating units installed in an eastern refinery, designed to burn refinery - refuse fuels and pulverized coal

TABLE 1—Typical Analyses of Three Refinery Substitute Fuels

Constituents	Per cent by weight: Bunker C oil	Per cent by weight: Acid sludge	Per cent by volume saturated with moisture at 62 F and 30 in. Hg: Refinery gas
Moisture	trace	17.5	..
Carbon	84.0	63.5	..
Hydrogen	12.5	8.1	..
Oxygen	1.2	..	1.2
Nitrogen	1.7	..	7.7
Sulphur	0.4	3.2	..
Ash	0.2	4.3	..
Oxygen plus nitrogen	..	3.4	..
Carbon dioxide	..	..	..
Carbon monoxide	..	..	0.3
Methane	..	..	36.3
Ethane	..	..	22.9
Propane	..	..	26.8
Butane	..	..	4.3
Pentane	..	..	0.5
Higher heating value:			
Btu per lb (dry)	18445	14341	..
Btu per cu ft	..	..	1590

present. Its composition is variable as a result of differences in the characteristics of the oil refined and the extent of cracking to which the oil has been subjected in order to extract gasoline. There are also present some illuminants, or unsaturated hydrocarbons from the cracking operations.

"For use in steam-generating units, the gas from several types of operations is mixed or blended. The characteristic flame from the blended gas, except for a distinct clear blue zone in the area of the burner throat, is colorless and extremely short. At times, however, the gas may be wet and contain some of the lighter phases of gasoline in the form of mist or vapor; when present these burn with small, intermittent, white, flashing flames.

"These gasolines are undesirable because of their comparatively slow-burning characteristics, which result in continuous or secondary combustion that may extend through a large portion of the boiler. As a result, efficiency is lowered because of increased losses resulting from higher boiler-exit temperature; and increased maintenance follows, because baffle and superheater supports are subjected to abnormally high temperature.

"Burners for refinery gas are similar to those used for natural gas firing, and are also arranged for using auxiliary liquid fuels. The gas ring or tube should be readily replaceable as there may be a tendency for orifice plugging from carbon accumulations when burning contaminated or wet gas.

"Furnace design limitations are the same as those for natural gas firing. Fully water cooled walls may be employed and maximum continuous heat-liberation rate should not exceed 20,000 to 30,000 Btu per cu. ft. per hour.

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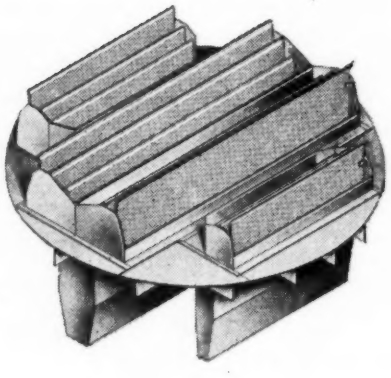

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CALCULATION OF PLATE COLUMNS FOR TERNARY DISTILLATION

By ROBERT R. WHITE, Associate Professor
and W. T. BOYD, Graduate Student
Department of Chemical and Metallurgical Engineering
University of Michigan

The two previous articles of this series* have dealt with the vapor-liquid equilibrium relations of multicomponent mixtures and the performance and design calculations for column sections, and rectifying and stripping columns. This article presents an analysis of the design calculations for complete columns distilling ternary mixtures with special emphasis on the important limiting case of minimum reflux. A thorough knowledge of this material is basic to an understanding of the fundamental principles underlying the distillation of the more complex mixtures encountered in the petroleum industry.

• • •

IN considering design calculations for columns fractionating ternary or multicomponent mixtures, it is necessary to specify clearly what separation of the feed is desired. In general, five variables must be fixed in order to define the fractionation of a ternary feed of a given composition and thermal conditions. Two of these variables are usually specified as the pressure under which the operation is to be conducted and the reflux ratio (L/V), or its equivalent, in the rectifying section. An additional variable usually specified is the introduction of the feed on the plate which gives the minimum plate requirement. The separation must then be specified by fixing the concentration of two components in the distillate product, in the bottom product or the concentration of one component in each of the products.

Design calculations for a complete column are illustrated by the following example.

A feed mixture containing 40.0 mol % pentane, 30.0 mol % hexane and 30.0 mol % heptane is to be separated into a distillate product containing 1.0 mol % heptane and a bottom product containing 1.0 mol % pentane. The feed is to be introduced as a saturated liquid (at its bubble point) to a column operated at one atmosphere pressure. Reflux is to be returned to the column at its bubble point temperature. Determine the relation between the reflux ratio (L/V) and the number of equilibrium stages required.

As in previous examples a column designed to operate at total reflux and zero capacity would contain the minimum number of stages for the separation specified. Also a column designed to operate at a minimum value of (L/V) and maximum capacity would require an infinitely large number of stages.

The overall material balance will be represented on a composition diagram such as is shown in Fig. 1 by a straight line BFD passing through point F representing the feed, the point B representing the bottom product and located somewhere on the locus of all mixtures containing 1.0 mol % pentane, and the point D representing the distillate product and lying somewhere on the locus of all mixtures containing 1.0 mol % heptane. The precise location of the BFD is a function of the reflux ratio and must be determined by plate to plate calculations.

Total Reflux

Considering first the case of total reflux, the point B must be so located that the composition of the distillate

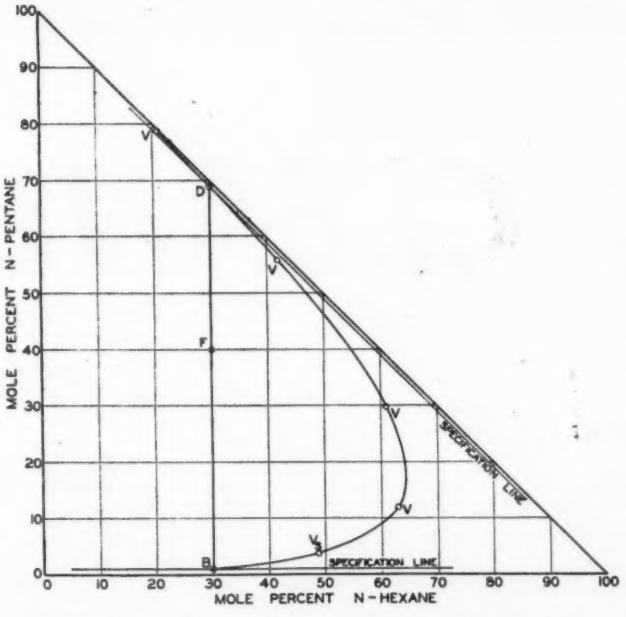
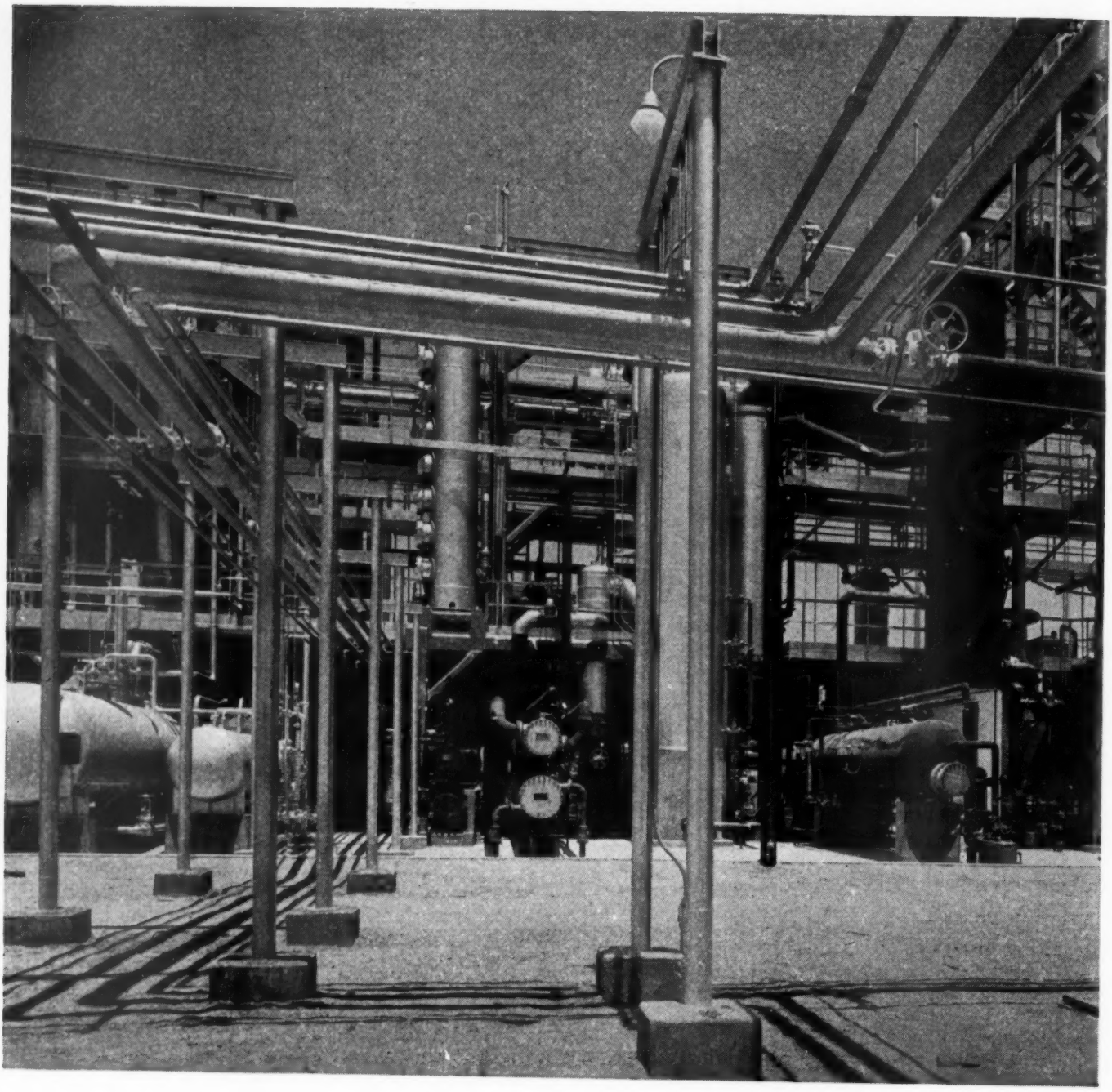


Fig. 1—Composition diagram for total reflux

* "Elements of Ternary Distillation," PETROLEUM PROCESSING, 2 (5), 371 (1947); "Stripping and Rectifying Columns for Ternary Distillation," PETROLEUM PROCESSING, 2 (11), 862 (1947).



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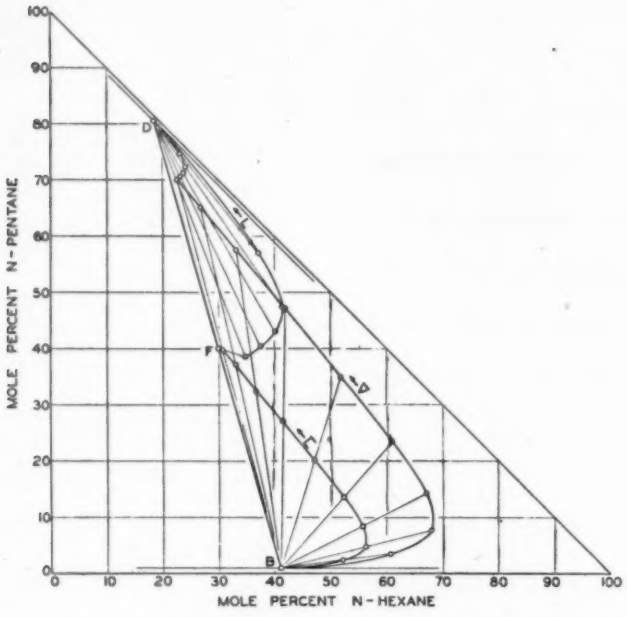

Fig. 2—Composition diagram for finite reflux

product D as determined from a material balance can be checked by a plate to plate calculation from the bottom product. In this case, a bottom product is assumed, locating the point B tentatively. The distillate product calculated by a material balance is then determined by extending the line BF to the distillate specification line of 1.0 mol % heptane, thus locating point D. Plate to plate calculations are now begun at the bottom product under total reflux conditions when the composition and quantity of a vapor rising from a stage are equal to that of the liquid leaving the stage above. Thus, the point V_s, representing the vapor in equilibrium with the bottom product and leaving the still, also represents the liquid stream leaving the stage above the still. The calculation is identical to those previously carried out for the operation of a stripping column at total reflux.(1) When a smooth curve drawn through the points determined by the plate to plate calculation passes through the point D determined from the material balance, the composition of the products has been established. The total reflux calculations for the problem under consideration are shown in Fig. 1, the number of equilibrium stages required being 4.6, including the still.

Finite Reflux

Consider now the calculation of the number of equilibrium stages required at a finite reflux ratio $R/D = \frac{1}{3}$. Again, the composition of the bottom product, B, is assumed locating the point B and the composition of the distillate product is calculated by a material balance locating the point D on the straight line BF and on the locus of mixtures containing 1.0 mol % heptane. The composition of the distillate product so determined must be checked by plate to plate calculations from the bottom product.

The plate to plate calculation from the bottom product is begun as has been described previously for stripping column calculations and as is shown in Fig. 2. The point B is the difference point for liquid and vapor passing one another in the stripping section of the column below the feed plate. Above the feed plate the point D is the difference point for the liquid and vapor passing one another in the rectifying section of the column.

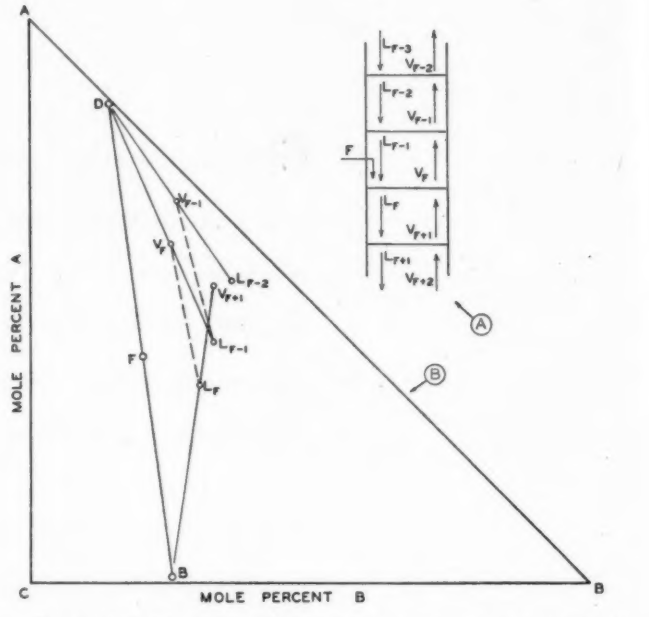

Fig. 3—(A) Diagrammatic section of column at feed plate. (B) Illustration of changing difference points at the feed plates

The change in difference points as the feed plate is passed in plate to plate calculations is illustrated diagrammatically in Fig. 3. The calculation of the number of stages required for the separation specified in the problem under discussion at a reflux ratio of ⅓ is shown in Fig. 2.

Feed Plate Location

In the previous discussion, the feed was introduced on the plate having liquid whose composition most closely approximated that of the feed. In general, introducing the feed on such a plate gives the lowest requirement of stages for the specified separation. However, the number of stages and, more important, perhaps, the composition of the products, is a function of feed location as well as reflux ratio. As in the case of binary systems at a given reflux ratio the feed may be introduced so far up the column that there will be an infinite number of stages in the stripping sections or it may be introduced so far down the column that there will be an infinite number of stages in the rectifying section. (The reader is especially urged to review the discussion of this point in binary distillation, PETROLEUM PROCESSING, Pg. 319, Dec. 1946).

The temperature and composition of vapor and liquid in zones of infinite plates may be evaluated as follows. In the rectifying section

$$V_{n+1} = L_n + D \quad \ldots\ldots (1)$$

and

$$V_{n+1}\, y_{n+1} = L_n x_n + D x_D \quad \ldots\ldots (2)$$

Since

$$y_{n+1} = K_{n+1}\, x_{n+1} \quad \ldots\ldots (3)$$

then

$$V_{n+1}\, K_{n+1}\, x_{n+1} = L_n x_n + D x_D \quad \ldots\ldots (4)$$

If a zone of infinite stages occurs in the rectifying

TABLE 1—Calculation of Composition in Zone of Infinite Stages Using Equation 5

FINAL TRIAL FOR CORRECT DISTILLATE COMPOSITION AND L/V=0.75

Component	Composition of Distillate		Assume temp. = 141° F., Final temp. trial			corrected
	x_D	$0.75x_D$	K_{141}	$K_{141}-0.25$	$\frac{.75x_D}{K_{141}-L/V}$	$\frac{.75x_D}{K_{141}-L/V}=x_\infty$
n-C_5	0.745	0.5587	2.022	1.772	0.3154	0.3156
n-C_6	0.245	0.1838	0.750	0.500	0.3674	0.3680
n-C_7	0.010	0.0075	0.274	0.024	0.3125	0.3164
	1.000	0.7500			0.9953	1.0000

section, the fractionation between two plates in the zone of infinite stages is zero so the $x_n=x_{n+1}$. Rearranging Equation 4:

$$\Sigma x_n=1.0=\Sigma\frac{(1-L/V)x_D}{(K-L/V)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Similarly, if a zone of infinite stages occurs in a stripping section

$$\Sigma x_m=1.0=\Sigma\frac{(\overline{L}/\overline{V}-1)x_B}{(\overline{L}/\overline{V}-K_m)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

The effect of feed location on the composition of the products at a finite reflux ratio of ⅓ for the problem being considered is determined first by introducing the feed so far down in the column that infinite stages develop in the rectifying section. A bottom product composition is assumed, thereby locating points D_1 and B_1 on the diagram shown in Fig. 4. Equation 5 is now applied to calculate the composition of the liquid in the zone of infinite stages. This calculation involves a trial and error computation of temperature in the zone until the summation of the x terms is unity, and is summarized in Table 1. The feed is now introduced just below the zone of infinite stages and plate to plate calculations are made down the column to check the original assumption of bottom product composition. The final trial is shown in Fig. 4.

Similarly, when the feed is introduced so far up the column that a zone of infinite stages develops in the stripping section, a bottom product composition is assumed and the temperature and composition of the liquid in the zone of infinite stages is calculated by Equation 6. The feed is now introduced just above the zone of infinite stages and plate to plate calculations are made up the column to check the distillate composition determined from the material balance. An alternative method is to calculate down the column from the distillate to check the composition of vapor and liquid at the feed plate. The final trial is shown in Fig. 5. These calculations are summarized in Table 2 and the results plotted in Fig. 6 as D_2 and B_2. Thus, as the point of feed introduction varies from infinitely low to infinitely high the distillate product composition varies from D_1 to D_2 while the bottom product varies from B_1 to B_2. At the same time the stage requirement varies from infinity through a minimum value and back to infinity. Obviously, in design problems the feed is introduced on the stage giving the minimum total stage requirement. Fig. 6 also indicates that introducing the feed too low in a column dilutes the bottom product and introducing the feed too high in a column dilutes the distillate product, both products meeting the original specification of the problem.

Minimum Reflux—Development of a Single Zone of Infinite Stages

At total reflux, feed location is immaterial and there is only one distillate and bottom product meeting the specifications. As reflux ratio is decreased there is a range of products meeting the specifications depending upon the feed location. As reflux ratio continues to decrease, the range of variation of product composition passes through a maximum and eventually becomes zero at minimum reflux just as it was zero at total re-

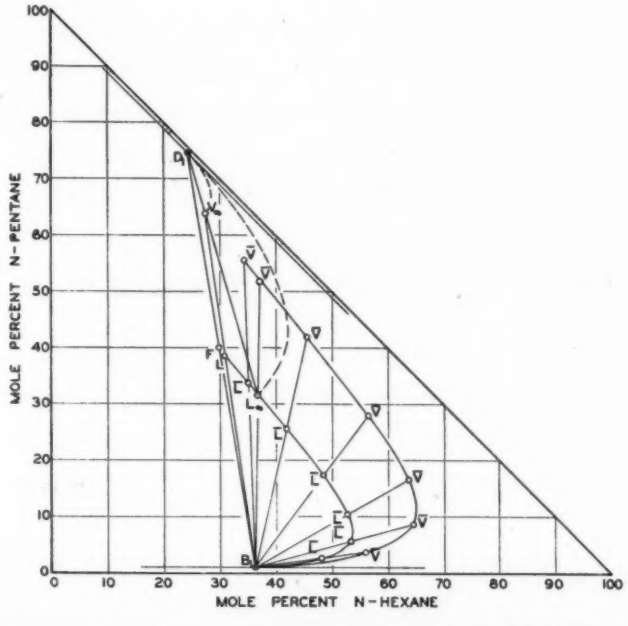

Fig. 4—Composition diagram where feed is added too low in column

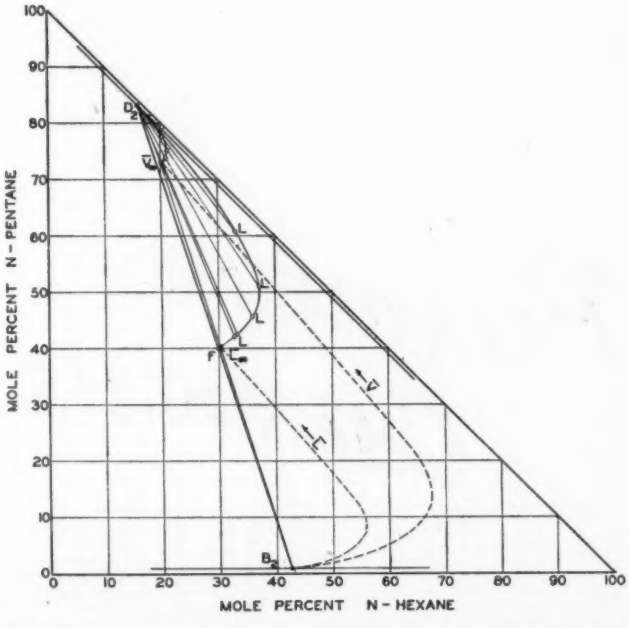

Fig. 5—Composition diagram where feed is added too high in column

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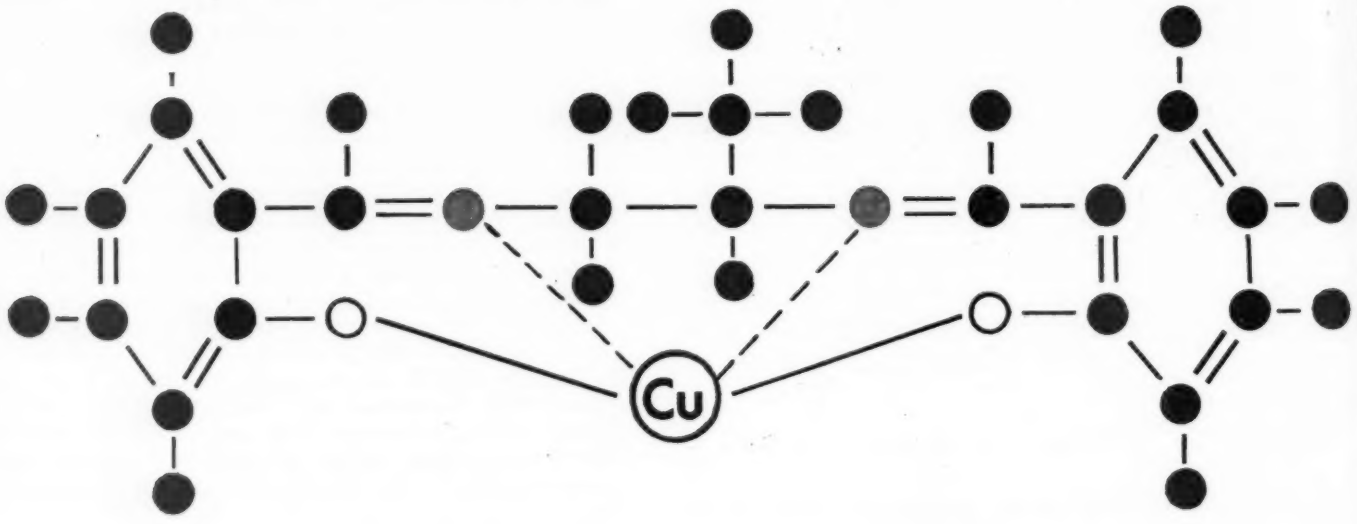

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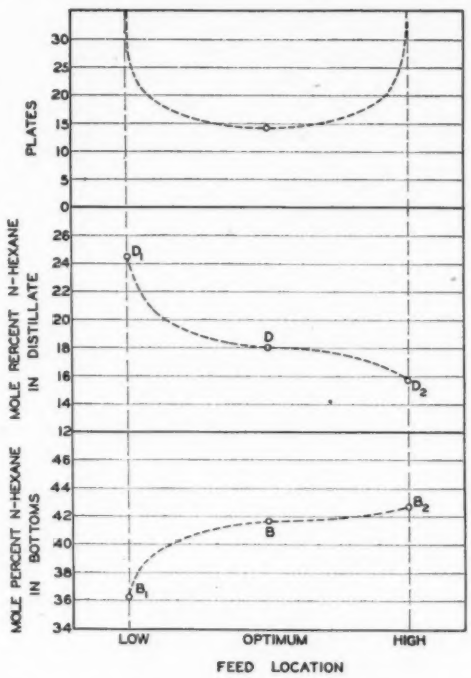

Fig. 6—Effect of varying feed location at finite reflux ratios

flux, only one distillate and one bottom product meeting the specifications at minimum reflux.

At the same time, as reflux ratio decreases, the distillate and bottom products produced *with the feed located at its optimum point* giving the minimum number of stages for each value of reflux ratio, tend to align themselves with the tie line through the point *F* representing the feed stream. In the problem under discussion, at minimum reflux the points representing the distillate and bottom products lie on the intersections of the extension of the tie line through the feed point with the specification lines representing 1.0 mol % heptane in the distillate product and 1.0 mol % pentane in the bottom product. This is illustrated in Fig. 7 which shows the paths of compositions in the column. Here the zone of infinite stages occurs at the feed plate at minimum reflux and results from the "closing in" of the extremities of the range of allowable feed location producing infinite stages either in the rectifying or stripping section.

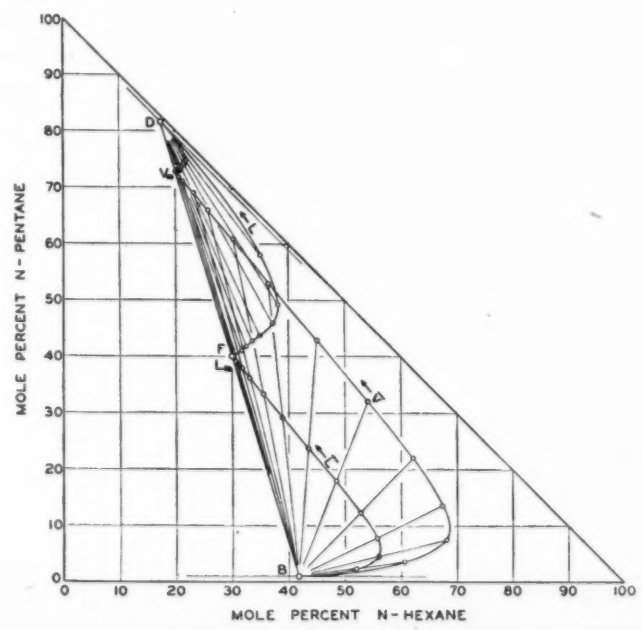

Fig. 7—Composition diagram for minimum reflux, illustrating single zone of infinite plates

The numerical evaluation of the minimum reflux is easily accomplished in this case by the application of Equation 5 or 6 to the known composition and tempera-

TABLE 2—Calculation of Composition in Zone of Infinite Stages Using Equation 6 and the Calculation of the Match at the Feed Plate

MATERIAL BALANCES

$L/V=0.25$, $V-L=D$

Assume D contains 0.832 mole fraction C_5.

By overall balance:

$F=D+B$

and by inverse lever arm principle:

$D/F=(.40-.01)/(.832-.01)=.474$

$\therefore D=.474$ if $F=1.0$, and $B=.526$

Thus, $V-L=.474$, and $L/(0.474+L)=0.25$

Solving, $L=0.158$, $V=0.632$ and $\overline{L}=1.00+0.158$, $\overline{V}=.632$

so that $\overline{L}/\overline{V}=1.832$

FINAL TRIAL FOR CORRECT BOTTOM PRODUCT AND L/V=0.25

Assume temp. = 133.75°, Final temp. trial corrected

Component	Composition of Bottom Product x_B	$.832x_D$	$K_{133.75}$	$1.832-K_{133.75}$	$\Sigma\frac{(\overline{L}/\overline{V}-1)x_B}{(\overline{L}/\overline{V}-K)}$	$\Sigma\frac{(\overline{L}/\overline{V}-1)x_B}{(\overline{L}/\overline{V}-K)}=x_\infty$
n-C_5	0.010	0.00832	1.811	0.021	0.3960	0.4033
n-C_6	0.426	0.35440	0.659	1.173	0.3020	0.3023
n-C_7	0.564	0.46920	0.238	1.594	0.2943	0.2944
	1.000	0.83192			.9923	1.0000

CALCULATION OF VAPOR IN ZONE OF INFINITE PLATES

Component	x_∞	$K_{133.75}$	$Kx_\infty=y_\infty$
n-C_5	0.4033	1.811	.7308
n-C_6	0.3023	0.659	.1992
n-C_7	0.2944	0.238	.0701
	1.0000		1.0001

PLATE TO PLATE CALCULATION DOWN TO THE COMPOSITION OF THE VAPOR FROM THE FEED PLATE

PLATE 1

Component	Distillate Product Composition y_1	K_{117}	y_1/K	corrected $y_1/K=x_1$	By material balance, $x_1+3x_6=V_2$
n-C_5	0.832	1.38	0.603	.6085	3.1045
n-C_6	0.158	.482	0.328	.3305	0.8045
n-C_7	0.010	.165	0.0605	.0610	0.0910
	1.000		0.9915	1.0000	4.0000

PLATE 2

Component	$y_2=V_2/4$	K_{123}	y_2/K	By material balance, V_3
n-C_5	0.77600	1.523	0.51	3.9060
n-C_6	0.20110	0.54	0.3725	.8465
n-C_7	0.02275	0.188	0.121	.1510
	0.99985		1.0035	4.0035

PLATE 3

Component	y_3	K_{127}	y_3/K	corrected $y_3/K=x_3$	By material balance, V_4
n-C_5	0.7515	1.628	0.4615	0.4570	2.953
n-C_6	0.2116	0.582	0.3635	0.3600	.834
n-C_7	0.03775	.2035	0.1857	0.1838	.2138
	1.00085		1.0107	1.0008	4.0008

PLATE 4

Component	y_4	$K_{130.75}$	y_4/K	corrected $y_4/K=x_4$	By material balance, V_5	y_5
n-C_5	0.7382	1.728	0.4272	0.4257	2.9217	0.7304
n-C_6	0.2085	0.624	0.3340	0.3329	0.8067	0.2017
n-C_7	0.0535	0.221	0.2422	0.2414	0.2714	0.0679
	1.0002		1.0034	1.0000	4.0000	1.0000

The composition y_5 checks the composition in the zone of infinite plates closely enough to consider the calculations matched at the feed plate.

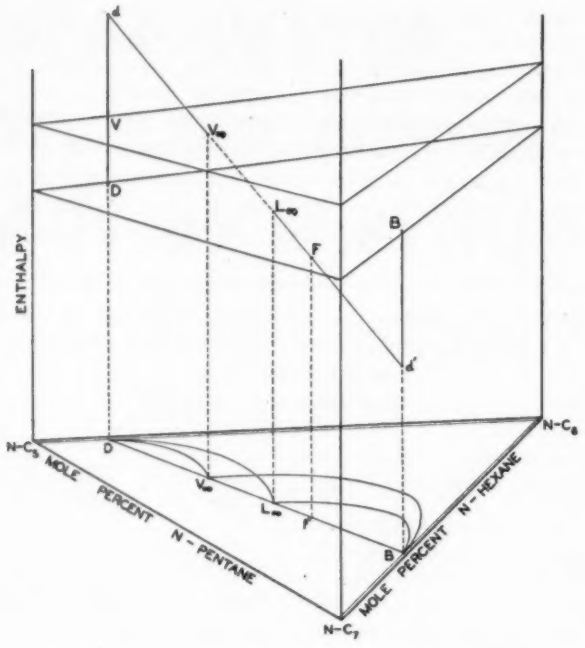

Fig. 8—Enthalpy-composition diagram for ternary system

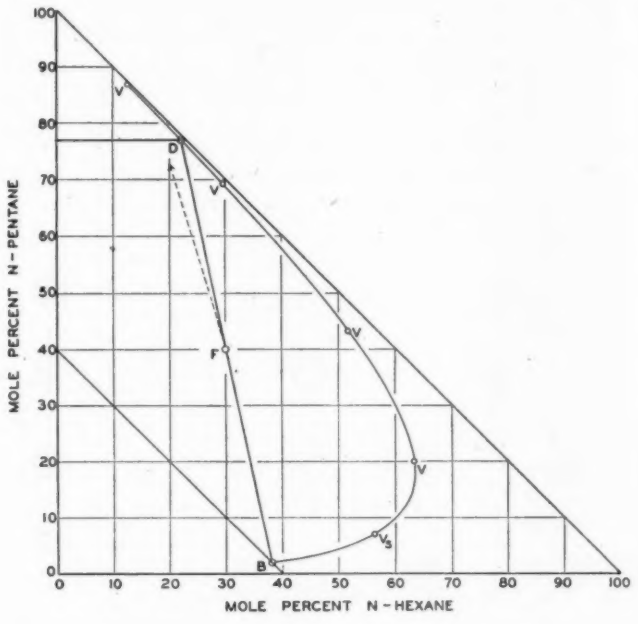

Fig. 9—Composition diagram for total reflux

ture in the zone of infinite stages. In the example shown in Fig. 7, (L/V)min.$=0.2118$ since the composition of the liquid in the infinite stage zone is the same as that of the saturated liquid feed. Where the feed is a saturated vapor, the similar relations hold except that the composition of the vapor in the zone of infinite stages is the same as that of the feed. Where the feed is an equilibrium mixture of liquid and vapor, the composition of the liquid and vapor in the zone of infinite stages is the same as the composition of the feed liquid and feed vapor respectively.

Where the feed stream is superheated vapor or unsaturated liquid, the ternary diagrams used so far must be thought of as the projection on a horizontal plane of a ternary enthalpy-composition diagram such as is shown in Fig. 8. Where the feed is a cold liquid the point F would lie below the surface representing saturated ternary liquids. The difference point d' for the stripping section would lie vertically below the point B representing the bottom product and lying on the saturated liquid surface. The difference point d for the rectifying section lies vertically above point D representing the distillate product. Minimum reflux is obtained when the line dFd' in space includes an equilibrium tie line. In

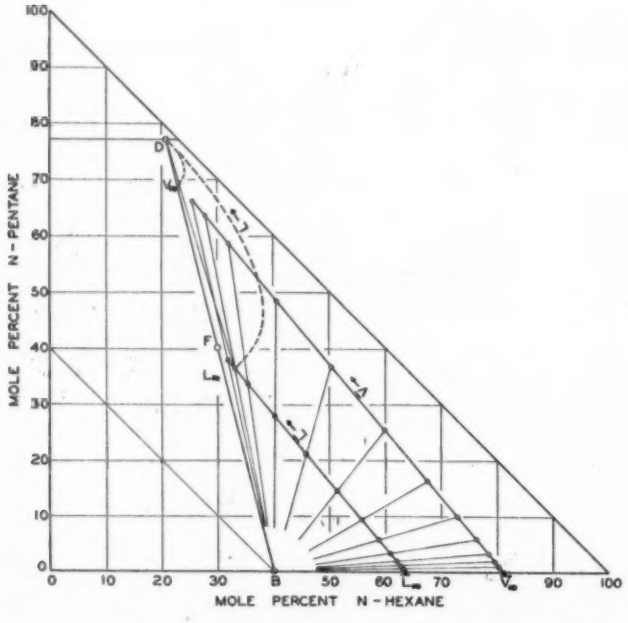

Fig. 10—Composition diagram for minimum reflux, illustrating two zones of infinite plates

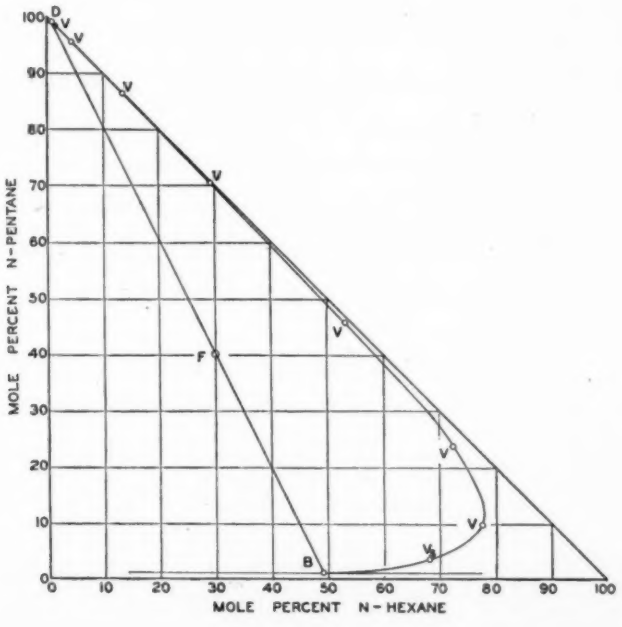

Fig. 11—Composition diagram for total reflux

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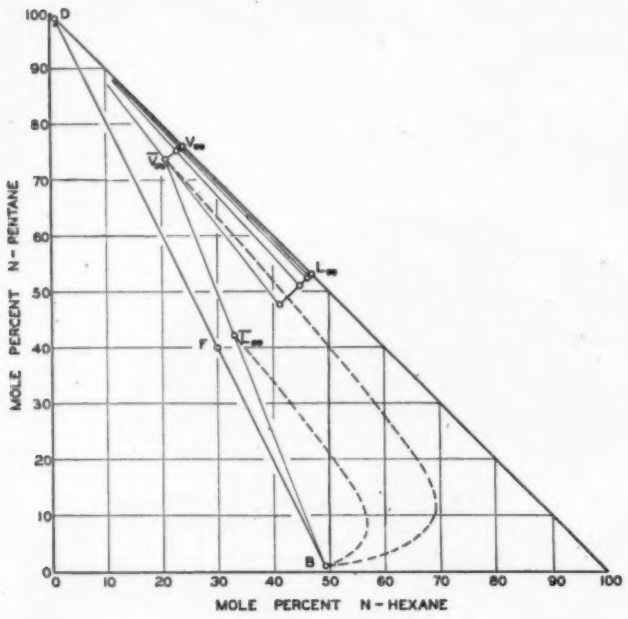

Fig. 12—Composition diagram for minimum reflux

this case the composition of the liquid in the infinite stage zone would be determined by finding the tie line which extrapolates through the point *F* in space.

Development of Two Zones of Infinite Stages at Minimum Reflux

It cannot be emphasized too strongly that the value of minimum reflux and the manner in which zones of infinite stages develop is a direct function of how the separation to be accomplished is specified. As an example, a similar problem will be considered specifying that the distillate product shall contain 77 mol % pentane and the bottom product 60% heptane.

The calculation of the number of stages required at total reflux is carried out as in the previous example. The results of this calculation are shown in Fig. 9. In order to ascertain the direction in which the products will shift as reflux is decreased, the equilibrium tie line through the point representing the saturated liquid feed is also shown. It has been shown in the previous example that as reflux is decreased from total reflux the products with optimum feed location will shift in the direction of aligning themselves with the tie line through the feed point and that when such an alignment was reached the value of minimum reflux and infinite stages was also reached. In this example as reflux ratio is decreased, the bottom product with optimum feed location reaches the hexane-heptane base before the line *BFD* coincides with the tie line through *F* so that at minimum reflux the bottom product lies on the hexane-heptane base.

The effect of varying the feed location gives a similar result. If at some reflux above the minimum the feed is placed so far up in the column that a zone of infinite stages occurs in the stripping section, the bottom product approaches the hexane-heptane base. On the other hand, if the feed is introduced so far down the column that a zone of infinite stages occurs in the rectifying section, the distillate product approaches the pentane-hexane base.

As the reflux ratio approaches the minimum the range of variation of the composition of the products with feed location approaches zero and one product (in this case the bottom product) is a binary mixture and the other is a ternary mixture, two zones of infinite stages developing simultaneously, one along the hexane-heptane base and the other at the bottom of the rectifying section. The zone of infinite stages in the stripping section developed in a manner similar to that previously discussed in the stripping column (Fig. 3, PETROLEUM PROCESSING, pg. 863, Nov. 1947) and that in the rectifying section is similar to the development of infinite stages in a stripping column (Fig. 10, PETROLEUM PROCESSING, pg. 867, Nov. 1947). This condition of minimum reflux is illustrated for the problem in Fig. 10.

In petroleum work, particularly in the fractionation of light hydrocarbons, the design engineer is interested primarily in "cutting" feed material between components. For example, with the feed mixture previously discussed in this article, it might be desired to recover most of the pentane from the feed as a single relatively pure product. Such a problem would constitute an example of "cutting" between pentane and hexane. The specification for a sharp cut between pentane and hexane is fixed by requiring a concentration of 99.0 mol % pentane in the distillate product. The specification for the sharp cut does not in itself insure complete recovery of the pentane in the mixture so that the additional specification of 1.0 mol % pentane in the bottom product is required for high recovery and a pure product.

These stringent specifications sharply restrict the variation in the composition of the products as reflux ratio is varied. This is shown in Fig. 11 where the points *D* and *B* represent the products corresponding to total reflux. As the reflux ratio approaches the minimum value, the distillate product goes to the pentane-hexane base but the variation in composition of either *D* or *B* is exceedingly small and can be neglected for practical purposes. At minimum reflux a zone of infinite stages develops along

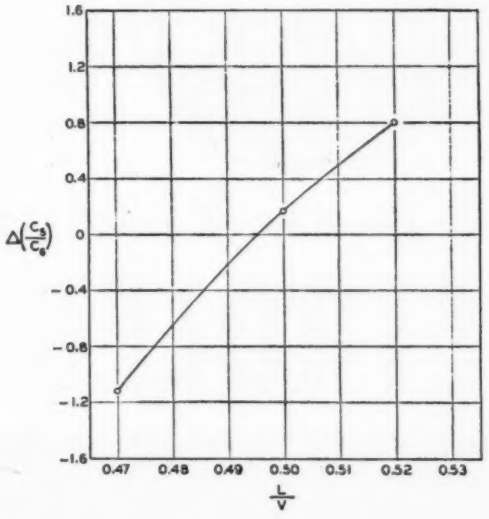

Fig. 13— Plot for determining correct minimum reflux

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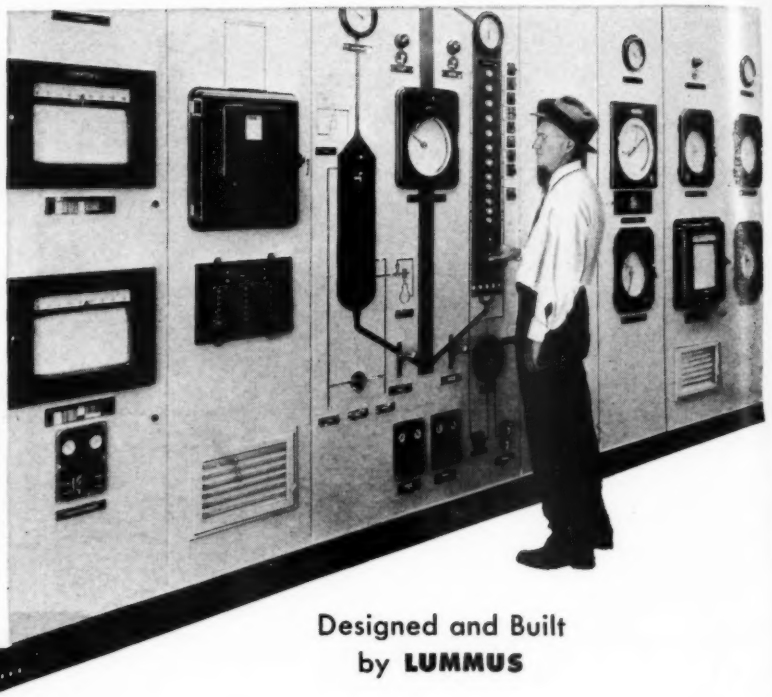

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TABLE 3—Calculation of Minimum Reflux

Top product composition

	x_D
n-C_5	0.99
n-C_6	0.01
n-C_7	0
	1.00

Bottom product composition by material balance

	x_B
n-C_5	0.01
n-C_6	0.4917
n-C_7	0.4983
	1.0000

By inverse lines arm principle:
$D/F=39/98=0.398$; $D=0.398$, $F=1.0$, $B=0.602$ by material balance
Choose $L/V=0.5$, so $V-L=.398$
Solving for L, $L=0.398$ and $V=0.796$
Also, $\overline{L}=L+F=1.398$, and $\overline{V}=V=0.796$, so $\overline{L}/\overline{V}=1.757$
and the equations for the two zones of infinite plates are:

$$\Sigma x_n=1.0=\Sigma\frac{(1-0.5)x_P}{(K_n-0.5)}=\Sigma\frac{0.5x_D}{K_n-0.5}$$

$$\Sigma x_m=1.0=\Sigma\frac{.757\,x_B}{1.757-K_m}$$

For binary zone in rectifying section

Component	x_D	$.5x_D$	$K_{120.1}$	$K-.5$
n-C_5	0.99	0.495	1.453	0.953
n-C_6	0.01	0.005	0.511	0.011
	1.00	0.500		

Component		Corrected		Corrected
	Σx_n	x_n	Kx_m	y_n
n-C_5	0.5195	0.5205	0.7565	0.7552
n-C_6	0.4550	0.4795	0.2452	0.2448
	0.9745	1.0000	1.0017	1.0000

For ternary zone in stripping column

Component	x_B	$.757x_B$	$K_{181.2}$	$1.757-K$
n-C_5	0.01	0.00757	1.740	0.017
n-C_6	0.4917	0.37200	0.628	1.129
n-C_7	0.4983	0.37743	0.222	1.535
	1.0000	0.75700		

Component		Corrected		Corrected
	Σx_m	x_m	Kx_m	y_m
n-C_5	0.4450	0.4250	0.7395	0.7390
n-C_6	0.3297	0.3292	0.2066	0.2064
n-C_7	0.2460	0.2458	0.0546	0.0546
	1.0207	1.0000	1.0007	1.0000

PLATE TO PLATE CALCULATIONS FROM THE BINARY ZONE INTO THE TERNARY ZONE

Let $L=1$, $V=2$, $D=1$
Quantity of D in moles: n-C_5=.99 moles, n-C_6=.01 moles
A small amount of n-C_7 will be added to the binary zone in order to calculate down to the feed plate.

PLATE 1

Component	y_n	$K_{120.1}$	y/K	$y/K+D=V_{n+1}$
n-C_5	0.7545	1.453	0.5190	1.509
n-C_6	0.2445	0.511	0.4780	0.488
n-C_7	0.0010	0.177	0.00564	0.00564
	1.0000		1.00264	2.00264

PLATE 2

Component	y_{n+1}	K_{121}	y/K	$y/K+D=V_{n+2}$
n-C_5	0.7528	1.476	0.5100	1.5000
n-C_6	0.2438	0.521	0.4675	.4775
n-C_7	0.002815	0.1805	0.0156	.0156
			0.9931	1.9931

PLATE 3

Component	y_{n+2}	K_{122}	y/K	$y/K+D=V_{n+3}$
n-C_5	0.752	1.50	0.5015	1.4915
n-C_6	0.2396	0.53	0.4520	0.4620
n-C_7	0.00782	0.183	0.04225	0.04225
	0.99942		0.99575	1.99575

PLATE 4

Component	y_{n+3}	K_{124}	y_{n+3}/K	$y/K+D=V_{n+4}$	y_{n+4}
n-C_5	0.7475	1.551	0.4820	1.4720	0.7311
n-C_6	0.2316	0.550	0.4208	0.4308	0.2143
n-C_7	0.02114	0.1925	0.1096	0.1096	0.0545
	1.00024		1.0124	2.0124	1.0000

From the composition, y_{n+4}, it is seen that the normal heptane is the same as that in the lower zone and that the calculations have been carried far enough.

Thus, for one point on the Δ(n-C_5/n-C_6), we have

$$\Delta(\text{n-}C_5/\text{n-}C_6)=(0.7390/0.2064)-(0.7311/0.2143)$$
$$=3.58-3.41=+0.17$$

Values of Δ(n-C_5/n-C_6) are calculated for two other reflux ratios in a similar manner and the results are plotted in Fig. 13. The actual minimum reflux from the curve is $L/V=0.4955$.

the pentane-hexane base simultaneously with another zone in the stripping section. This is shown in Fig. 12. At intermediate reflux ratios, the line of fractionation approaches the binary system pentane-hexane very closely without encountering infinite stages and the calculation becomes one of binary distillation.

The calculation of the minimum reflux is accomplished in the following manner for the numerical problem being discussed.

Step 1. A minimum reflux ratio is assumed and the liquid and vapor rates above and below the feed plate are calculated.

Step 2. The overall material balance around the column is fixed. This is predicated upon a knowledge of the effect of reflux ratio in shifting the composition of the distillate and bottom products.

Step 3. The composition in the binary zone of constant composition is calculated by usual binary methods from the reflux ratio and the composition of the binary product.

Step 4. The composition in the ternary zone of constant composition is calculated from the ternary product and the reflux ratio.

The calculation indicated in Step 4 may be carried out out by means of Equations 5 and 6.

Step 5. Using the concentrations of the binary zone of constant composition, a small arbitrary amount of the missing component is added and plate to plate calculations are made until the vapor compositions match at the feed plate. If the vapor compositions do not match the correct value of minimum reflux was not assumed.

Ordinarily, it is convenient to plot the difference between the ratio of the specified components appearing in both the distillate and bottom products as given by Steps 2 and 5 as a function of the assumed reflux ratio. The minimum reflux ratio is then read from the resulting curve, Fig. 13, when the difference is zero.

This procedure is illustrated by the calculations for the column, which are presented in tabular form as Table 3.

Reference

(1) White, Robert R, and Boyd, W. T., *Petroleum Processing*, 2 (11), 862 (1947).

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Maintenance of Stainless Steel Equipment in Refineries

ARTICLE 2—Stress and Local Corrosion, Wear and Abrasion, and Cleaning Methods

By W. G. RENSHAW

Research Chemist, Allegheny Ludlum Steel Corp.

Although stress corrosion in stainless steel equipment can best be prevented by careful design, fabrication, and installation so as to avoid setting up stresses, a number of operating conditions are also contributing factors to the problem. Examples given include pressure reversals, cyclic vibrations, nonuniform heating, and the like.

Emphasis is also placed on thorough and periodic cleaning for best service. Turbo cleaning is recommended for coke removal from heater tubes; other deposits are most frequently treated with acids, preferably nitric. In his second article, the author also warns against users pushing equipment beyond design specifications, and discusses problems encountered in refrigeration and hydrogenation, as well as methods for handling wear and abrasion.

NEARLY all metals may be subject to stress corrosion under certain conditions of service. The austenitic chromium nickel-stainless steels are included in this group of metals. However, relatively few cases are known where the straight chromium steels have failed from this cause.

Two distinct kinds of stresses may exist. One of these, "plastic" stress, only in some instances has caused stress corrosion failures. Many metals have the desirable physical properties which make it possible to bend and form them into various shapes, and even to roll them from heavy to thin sheets when cold. Actually there is some flow of the metal to relieve any pressure or strain applied, and thus no constant static stress exists in the material. For example; if a strip of metal an inch or so wide were bent to a 90° angle and then allowed to remain untouched with no further forces applied, it would remain bent at exactly the same angle indefinitely with no tendency to return to its original condition.

In such a case the yield strength of the particular metal used was exceeded in the outer tension fibers of the bend and the metal actually began to flow to relieve the forces applied. When bending was completed the metal would be said to have a new "set," since it will not return to its original shape because it is not sufficiently elastic to do so, although it does possess some small amount of elasticity. A metal spring that has been stretched too far also will not return to its original position for the same reasons.

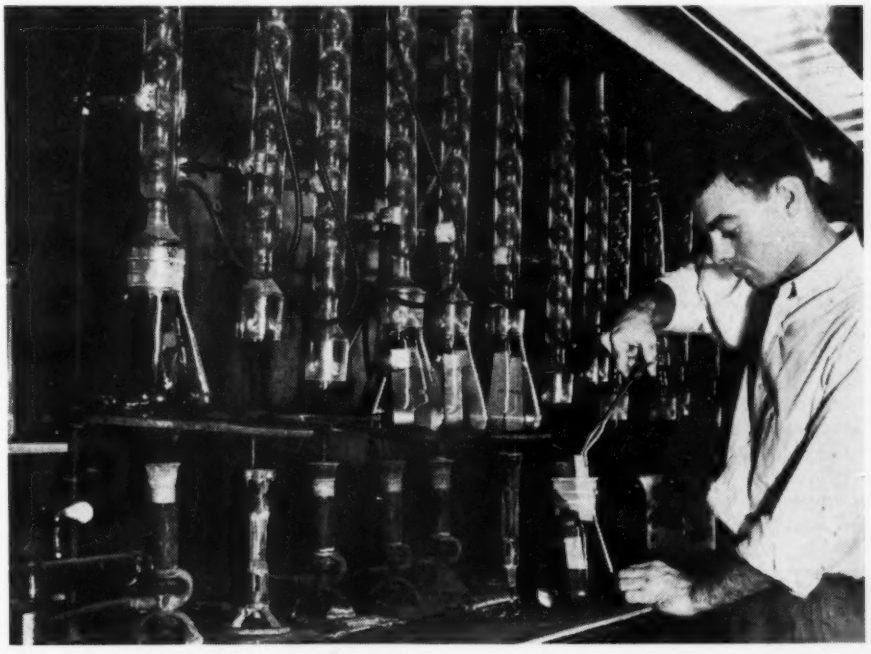
Other operations such as cold rolling and cold straightening also may cause plastic stress. In cold rolling the squeezed or compressed metal cannot again return to its original thickness. In cold straightening the metal will not spring back to its original shape like a rubber band. Plastic stresses are usually fairly uniform and probably not too severe since the metal flows to help relieve the applied pressures. Only in a few isolated cases has this type been known to cause failure by stress corrosion.

The far more severe locked-up or residual stresses resulting from fabrication usually are responsible for stress corrosion failures. In the fabrication of equipment where several parts are joined by welding or riveting, it often occurs that certain of the parts may not be exactly the right size or shape for their intended position. If these are forced or hammered down and then securely welded or joined to the rest of the unit, stresses are locked up in the equipment.

In this instance, there has been no plastic flow and a constant stress is being applied to the part in question. If it were cut free from the equipment the part probably would spring back to its original shape to relieve the stress. These stresses are usually not uniform and in some locations areas in tension are immediately adjacent to others in compression.

It is thought that small electrochemical cells may exist at the surface of the metal when it is stressed and placed in certain solutions which can act as the electrolyte. The areas in tension would probably be anodic to the rest of the surface, since cracking has been noted to occur under tension stress in specimens examined.

When two areas immediately adjacent are in tension and compression,



Typical routine laboratory testing of the corrosion resistance of stainless steel alloys

the potential difference of the electrochemical cells would probably be greater and might account for greater susceptibility to cracking when stresses are not uniform. Stress corrosion is not characterized by cracking alone. In some solutions, it may be found that stresses cause no cracking but instead pitting or localized attack will occur. With other solutions, both cracking and localized attack may take place in stressed material.

Little Known as Yet

Actually, relatively little is known about the mechanism of stress corrosion. Attempts have been made to study this particular type of corrosion by laboratory tests, but results have been irregular. Even duplicate specimens tested simultaneously frequently show widely varying results. Solutions which may be able to cause stress corrosion failures under service conditions may not be at all effective in laboratory tests. Results of laboratory tests cannot be translated into any useful specifications or rules which could be applied to service conditions.

However, it is by far better to prevent the setting up of stresses in fabrication than to try to determine what stresses should be permitted for service conditions. In fabrication it is essential that parts to be joined fit exactly. The use of welding jigs or clamps to hold parts in place in their correct position before welding will aid greatly in assuring freedom from stresses.

In addition, such jigs also aid as chill bars or plates which will conduct heat away from the weld area more uniformly and reduce carbide precipitation as well as prevent some distortion or warping from uneven heating in the welding procedure. This distortion or warping can set up nonuniform stresses. It is therefore almost essential to make use of these welding jigs and correctly position all parts to be assembled if a finished unit as free as possible from all harmful stresses is desired.

Annealing Not Always Done

While annealing of finished equipment is sometimes employed to assure that stresses are removed, this involves expense and is often impossible with very large units. Removal of scale after annealing would then be an additional necessary operation. However, annealing should be necessary only in extreme cases and would be superfluous if fabrication is carried out with careful consideration for preventing the locking-up of stresses in equipment.

It should be mentioned that two types of cracking may occur. If stresses and precipitated carbides are present the cracking will be intergranular, while it usually is transgranular or across the grain when stresses alone are present. It is necessary to keep carbide precipitation at a minimum since carbides will accelerate stress corrosion failure to a marked degree.

While cases of stress corrosion are not very common, the factors which cause it should be recognized by fabricators. Design of equipment is important also, and allowances should be made for cases where operational specifications may be exceeded with resulting stresses in otherwise satisfactory equipment.

Where operators of such units wish to exceed operational specifications, they should also be familiar with the factors which can cause this type of corrosion and recognize the possibilities of costly failures and necessary shutdowns for repairs.

Occasionally, stresses may be encountered in service which the designer or fabricator would not expect or foresee during construction of equipment. Pressure reversals in some process may occur. Perhaps some deposit in a tube may become great enough to cause backup of pressure.

Vibration Is Common

Vibrations or cyclic stresses are common. Applications involving condensation of steam are subject to vibrations. Lines situated near pumps sometimes have cyclic stresses due to pressure increases or spurts in each pumping cycle. In other cases alternate filling and emptying of tanks can result in cyclic stresses.

Sometimes overloading a tank beyond a certain specified capacity will cause harmful stresses to be set up.

Where equipment is heated in service, stresses may occur due to nonuniform heating causing warping or distortion. Alternate heating and cooling in certain processes may cause cyclic stresses.

While many of these service stresses can be avoided, in some instances this is impossible. However, it should be borne in mind that the presence of such stresses does not necessarily mean stress corrosion failures. Many other conditions, such as type of solution and temperatures, are also factors. In all instances, locked-up fabrication stresses must be avoided since a combination of these with service stresses might cause rapid failures.

Localized Corrosion

Pitting or localized attack is common to all metals. When this type of corrosion occurs, small localized areas may be attacked very severely and adjacent surrounding areas on the surface not show any corrosion at all. These localized pits become progressively deeper as attack continues but usually do not spread out over the surface. This pitting is probably accelerated by electrochemical cells, with the small attacked areas being anodic to the unattacked surrounding cathodic areas.

While lack of corrosion resistance of the metals accounts for localized pitting in some cases, often certain factors can be controlled. For instance, surface contamination, such as deposits or annealing scale, can provide the necessary conditions for concentration cells to be set up which will cause pitting. The necessity of clean, smooth surfaces free from contamination cannot be emphasized too greatly in preventing corrosion of any metals.

Avoid Sharp Corners

Crevices, cracks and sharp corners must be avoided in the design and fabrication of equipment. Where these exist, solutions are able to remain stagnant and undisturbed by the main body of the solution. The deepest parts of these surface defects do not have the same opportunity to be in contact with air or oxygen (dissolved in solution) as the surface of the metal.

The resulting differential aeration causes an electrochemical concentration cell to be set up which is very damaging, and corrosion progresses at a rapid rate in the form of pitting or localized attack at these places. This can be eliminated by design so that no such sharp corners or joints with deep crevices will exist. However, another simple way of correcting this difficulty is to lay a deposit of weld metal over the cracks or crevices or in the sharp corners to round them off.

The concentration cell type of pitting resulting from surface deposits, or from cracks, crevices and sharp corners, can be avoided only by proper care and design. This type of attack can occur with all metals.

Contact with Other Material

In construction of some plant equipment, it is sometimes necessary to place stainless steel in contact with other materials of construction, such as brick, concrete, tile, stone and even wood. None of these substances should be harmful to stainless steels provided no moisture is present. However, moisture is often present even from the surrounding air or from steam condensation and often drippings or splashings creep into the space between a stainless steel tank and its reinforcing wall.

Here again, we find ideal conditions for concentration cell corrosion, since the liquids in the crevices between the stainless steel and the other materials have a chance to become stagnant with very little access to air. It should be pointed out, however, that other metals used in place of stainless steel in such an application would also be subject to

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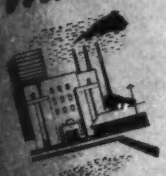

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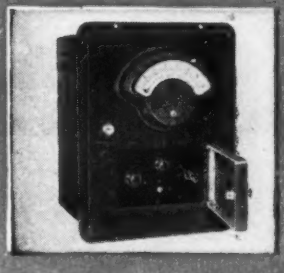

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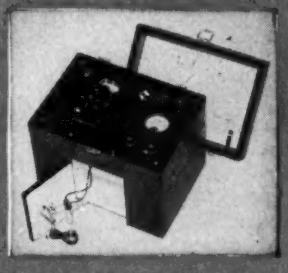

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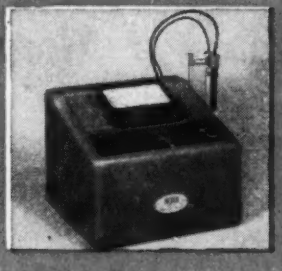

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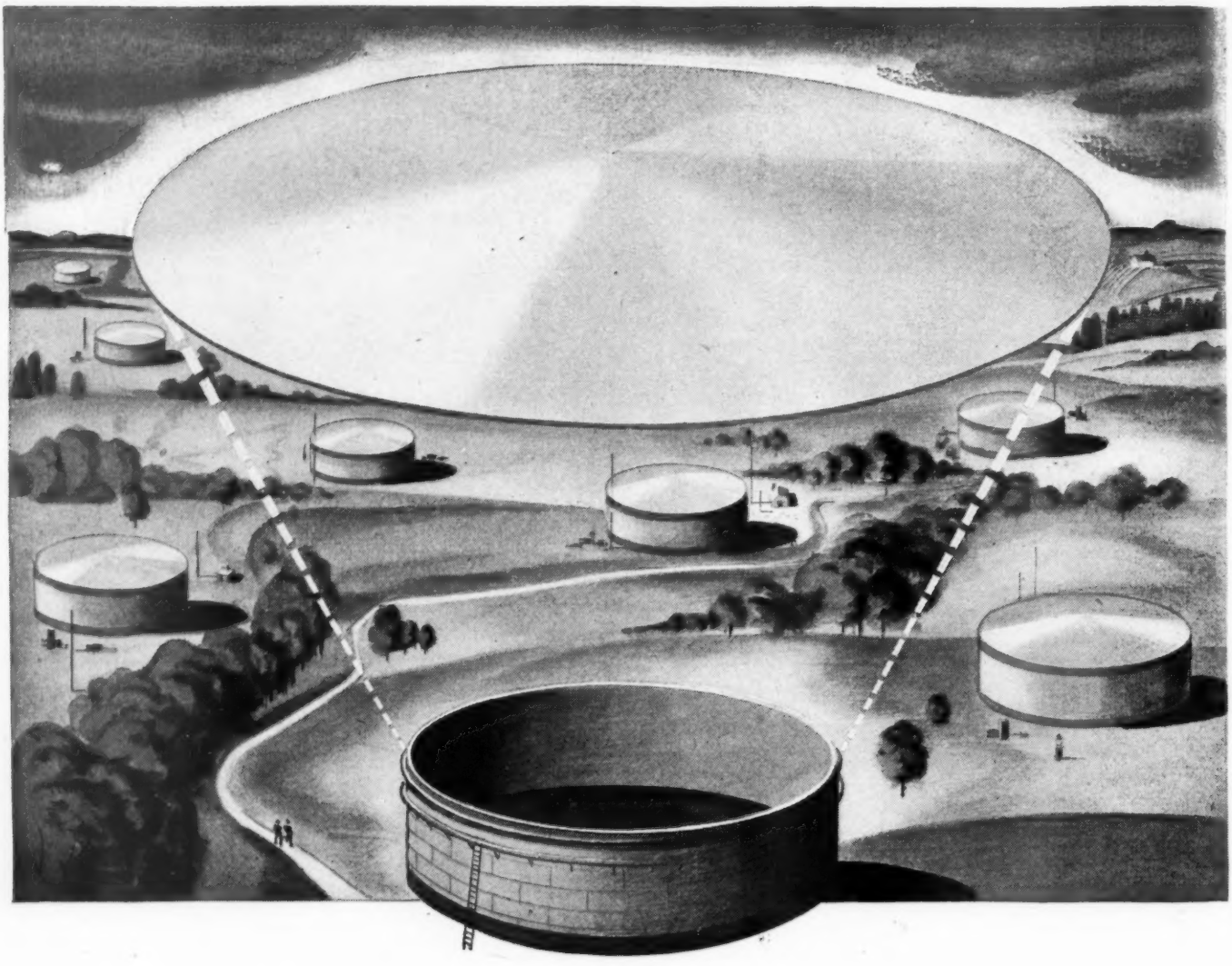

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the same difficulties of pitting by these concentration cells.

Since it is sometimes necessary for stainless steel equipment to be reinforced with other materials because of certain construction regulations, or where stainless steel floors are to be placed over existing floors of wood or other material for either appearance or possible reasons of cleanliness and sanitation, the use of some coating on the stainless steel is recommended for the surface to be placed in contact with other material. Asphalt-base coatings, which keep moisture away from the stainless steel surface, are very suitable, and have been used with a great deal of success in many applications.

Contact of stainless steels with other metals should also be considered in this discussion. Stainless steels stand very low in the electrochemical series, slightly below copper. Stainless and copper in contact usually give very satisfactory service because their potentials are very nearly the same. However, other metals higher in the electrochemical series than copper may suffer galvanic attack when placed in contact with stainless steel, although the stainless steel, being cathodic to them, will not be affected.

Brines

In connection with pitting of stainless steels, brines contaning chlorides may cause such attack unless care is employed in handling them. Brines should not be permitted to remain stagnant for any period of time in contact with any stainless steel. The presence of contaminating iron salts in such brines is especially dangerous and should be avoided. Type 304 in some instances is suitable for handling brines, if the brine is maintained at a pH above 8. Where the pH might drop below 8, it is advisable to use Type 316, which has better resistance to pitting by chloride solutions because of the molybdenum addition to the alloy. (Note: See Table 1 for analyses of stainless types.)

Cleaning is Essential

It can be seen that certain necessary precautions must be observed in the design and fabrication of new equipment and in the revision of existing equipment intended to meet different specifications of operation, in order to assure that the equipment is in its best possible corrosion resistant condition before being placed in service. The maintenance of the protective film during service is just as important.

The stainless steels, due to numerous careful finishing operations by the manufacturers, possess a uniform, dense surface condition which accounts for their good corrosion resistance. This hard dense surface is largely responsible for the fact that coke frequently formed in phases of the refining processes does not adhere as readily to stainless steels. However, some deposits do form, as well as other kinds of foreign contamination, and interrupt the smooth clean surface of these metals.

TABLE 1—Selected Stainless Steel Type Numbers and Analyses

(Issued by the American Iron and Steel Institute)

Type No.	Carbon	Chromium	Nickel	Other Elements
*302	Over .08-.20	17.50-19.00	8.00- 9.00	
302B	Over .08-.20	17.50-19.00	8.00- 9.00	Si 2.00-3.00
†304	.08 Max.	17.50-19.00	8.00- 9.00	
310	.25 Max.	24.00-26.00	19.00-21.00	
†316	.10 Max.	16.00-18.00	14.00 Max.	Mo 2.00-3.00
321	.10 Max.	17.00-20.00	7.00-10.00	Ti Min. 4 × C
347	.10 Max.	17.00-20.00	8.00-12.00	Cb 10 × C
410	.12 Max.	10.00-13.50		
440	Over .12	14.00-18.00		
446	.35 Max.	23.00-30.00		

* No specified composition limits within the above ranges may be placed on these Types, except carbon may be specified to a four-point range within the above limits.

† In these types manufacturers may accept specifications and furnish material with a guaranteed carbon content of .08 maximum.

Accumulations of these deposits constitute a potential source of corrosive attack due to the creation of electrolytic cells or concentration cells. The rate at which the attack takes place depends upon the time the deposit is allowed to remain on the surface. The presence of harmful sulfur compounds helps to accelerate the action of these cells. Surface deposits can be easily removed when they are soft but, when allowed to remain, become progressively harder and removal may become rather difficult. The effects of heat help to hasten the hardening of these deposits, and at the same time the rate of heat transfer is materially decreased. When such a condition occurs, heat is not conducted away from the metal at these areas as rapidly and hot spots or overheated areas may develop which can accelerate corrosion and affect physical properties.

Removing Coke Deposits

The major point for emphasis in the maintenance of stainless steel equipment is that it be cleaned thoroughly and periodically. In many industries chemical or solvent treatment is sufficient to clean solid deposits from the surface. In the petroleum industry, the coke deposits are a source of difficulty since they are essentially solid deposits of hard carbon which cannot be removed by ordinary chemical treatment. Where these deposits must be removed frequently such as in heater tubes, a mechanical method of turbo cleaning is employed. While this removes some of the metal at the same time as the deposits, nevertheless it is probably the most effective way.

Over long periods of time, repeated cleanings do, of course, reduce the wall thickness appreciably and it is usually advisable to make hydrostatic tests before the tubes are reinstalled. Particular care must be used to prevent deformation of the tubes by the action of the turbo cleaner on the ductile stainless steel. Small bulges in the walls resulting from too severe mechanical action are ideal places for coke to form and build up into heavy deposits. At these places, overheating and possible failure can occur if the creep stress is exceeded, and there is the probability of severe corrosion which has been accelerated by higher temperatures.

Burning is Dangerous

Burning coke deposits from the surface is not advisable with stainless steels. Such a method involves heating by means of a flame to at least a red heat. Above 1500° F., the austenitic stainless steels can be carburized under the proper conditions, such as would exist in this procedure of burning coke. Carburization is assumed to tie up chromium in the form of carbides. When this occurs the stainless steel suffers a considerable loss in ductility and toughness as well as some loss of corrosion resistance.

Where the austenitic alloys are carburized and held in the temperature range of 800° F. to 1500° F., the precipitation of harmful carbides is even more severe and the alloy is even more susceptible to intergranular attack under corrosive conditions of service. In addition, carburization can decrease the oxidation resistance of the stainless steels appreciably, and scaling may become excessive with resulting high metal losses.

It is for these reasons that coke deposits should not be burned off stainless steel equipment but, instead, the more preferred mechanical method should be used. Obviously, if areas are locally heated by the burning method, it is probably likely there will be some carbide precipitation, since the metal will be held in the carbide range of 800° F. to 1500° F., even if no carburization takes place.

For the same reason acetylene welding is rarely employed for stainless steels, since the heated metal is subject to carburization by the hydrocarbon in the welding gas. If very carefully controlled, it can be used, but this is difficult. When insufficient oxygen is used in the flame, carbon is available to carburize the

metal; if too much oxygen, there will be no carburization but the metal will be severely oxidized.

The straight chromium steels can be carburized if they are heated to a sufficiently high temperature that their structure becomes austenitic. The 28% chromium Type 446 is not austenitic at any temperatures which would be employed in normal service for this alloy and, therefore, possesses the best resistance to carburization of the stainless steels.

Other Surface Contaminants

While removal of coke deposits is probably of most importance, other types of contamination and deposits may be encountered in other phases of refining. For example, condenser tubes may accumulate mineral scale deposits or possibly organic materials from the water circulated through them. The electrolytic cell type of corrosion may occur in such areas. In addition, the rate of heat transfer is appreciably decreased.

Certain acid solutions may be used to remove such mineral deposits. The most suitable solution is probably dilute sulfuric acid to which either copper sulfate or some good organic type of inhibitor has been added. Such a cleaning solution should be kept in motion or circulated since it will require some time to remove the deposits, and the solution is more effective if not allowed to become stagnant.

Nitric acid solutions are frequently used since they will not attack stainless steels. Any strength nitric acid solution can be held in contact with the stainless steel as long as necessary to remove the deposits. When brass, copper or other metals soluble in nitric acid are used in such systems, this particular solution must not be employed.

While the use of refrigeration in petroleum refineries seems to be minor compared to the gigantic stills and cracking units; nevertheless, it is used in the production of lubricating oils. Sometimes the systems are direct-expansion where ammonia is led directly to the chilling equipment and allowed to expand from liquid to gas. Stainless steel has excellent corrosion resistance to ammonia and is used extensively for refrigeration.

Acid Brines Harmful

However, in many installations, the ammonia expansion process is used to cool a brine which is then circulated to the location where refrigeration is necessary. Such brine systems usually employ calcium chloride or sodium chloride solutions. Calcium chloride is alkaline in nature normally but may turn acid on exposure to air.

Stainless steels are often used to handle these brine solutions when they are not acid or when iron salts are not present along with the brines. Acid brines, or those with iron salts present, are harmful whenever they are allowed to remain stagnant in contact with the metal for long periods of time.

Condensation

The problem of condensation of vapors in refineries is important because the presence of sulfur compounds allows the formation of sulfurous or sulfuric acid where water vapor is present. In cases where temperatures are high, i.e., above 800° F., usually only gases are involved. Type 410 has been satisfactory for many such applications.

As temperatures become lower than 800° F., however, Type 316 is usually more suitable because it has good resistance to pitting and attack by sulfur dioxide or sulfur trioxide in the presence of water vapor. For example, in some stills where the temperatures at the top may be low, it might be desirable to use Type 316 at this point to resist pitting, while in the lower hotter sections Type 410 would probably be satisfactory.

Some condensers may handle vapors with no corrosive substances present but these cases are rare, since most oils do contain small amounts of sulfur compounds or chlorides. Temperature and pressure of the vapors have a definite relation to the corrosion which may be found in condenser tubes in these instances. No certain alloy is suitable for all types of condensers, and each different case must be studied before a suitable metal is selected. Type 316 in many cases gives good resistance to pitting by condensing vapors.

Operational Specifications

Frequently, when the operator of a refinery unit or process has had good service from the stainless steels, he assumes they can stand more severe operations than the normal conditions he has been using. The result is that many stainless steel units are pushed beyond the design capacity. Perhaps the alloy is overheated by the change in conditions. Coking can become severe, and often the overheated material fails because it does not have sufficient strength at the higher temperatures involved.

In instances where areas are overheated and held in the carbide precipitation range for some period of time, failure may occur because of intergranular attack if some corrosive agent is present along with the oils and vapors. Perhaps the pressure increases under these stepped-up operating conditions and failure may be encountered where the creep strength is exceeded, even when the normal operating temperature has been maintained. If units are not cleaned often enough because the production demand prevents shutdowns at proper times, it is usually necessary to increase pump pressures to maintain the flow rate that existed before considerable coking had occurred.

Improper furnace design, high gas or flame temperatures, and direct impingement of the flame on metal, all contribute to overheating. Uniform heating is desirable. An effective measure in accomplishing uniform heating is to use large capacity units and maintain lower operating temperatures, rather than to use small units at higher temperatures. On the other hand, in many instances a uniform velocity and flow has not been maintained in a unit. Where flow has slowed down for a short period of time, there is again overheating, and slower rates of flow also tend to increase coking.

Wear and Abrasion

Wear and abrasion of metals are always an important problem. While no specific answer can be given because many varying conditions of both wear and corrosion combined are met in the petroleum industry, many such applications do use the stainless steels. The hardenable straight chromium alloys have been found especially useful in valves and pumps. For example, pump pistons and plungers made from 12% chromium steels heat treated to 350 or 400 Brinell have been very satisfactory. Such an application requires an alloy with good resistance to corrosion and abrasive wear as well as ability to stand high stresses.

Caution should be used in starting equipment which has 18-8 wearing surfaces, since these alloys have a tendency toward galling, seizing, or scoring in some instances. When starting reciprocating pumps with 18-8 rods, packing should be kept fairly loose at first and then gradually tightened after the pump has operated for a while. Scoring of the rod will be prevented and the service life of the rod greatly extended.

Regardless of the kind of metal used for construction of equipment, a proper knowledge of the metal, its corrosion-resisting and physical properties, fabrication and maintenance, is necessary on the part of the users in order to obtain the most possible service from the equipment.

Where problems arise that the petroleum engineer alone cannot solve, a combined effort with the manufacturers of the alloys can usually accomplish what neither one alone could do. While stainless steels have excellent corrosion resistance and unusually good physical properties, neglecting to give them proper care may cause premature unexpected failures.

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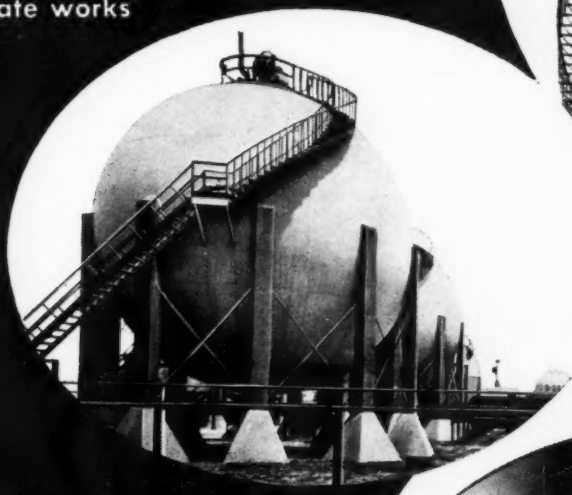

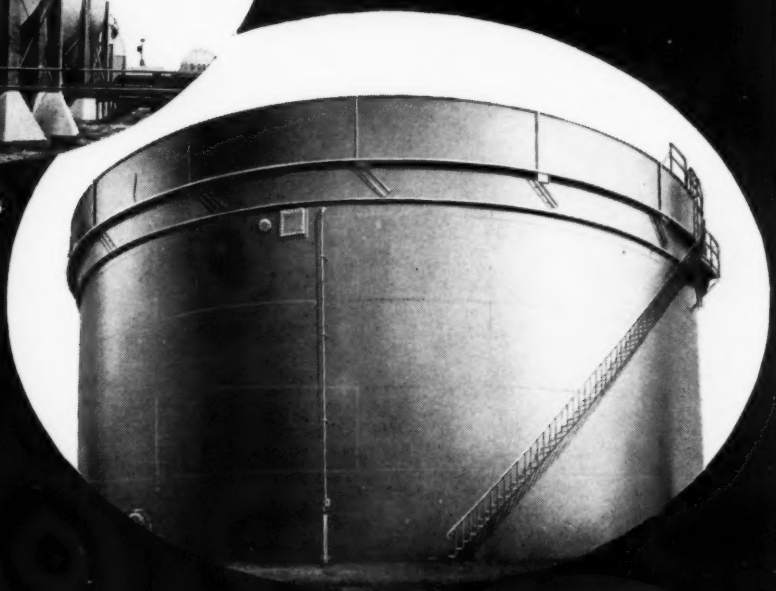

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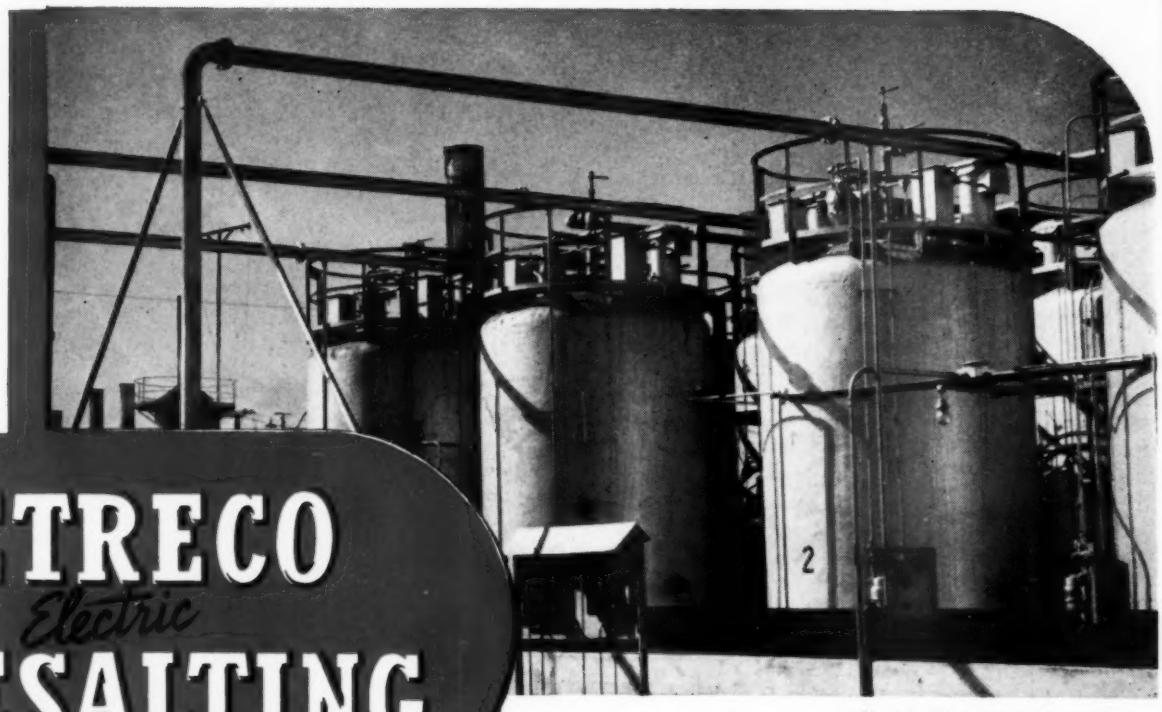

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PR 48-1

Patent Trends in Petroleum Refining

By PETER J. GAYLOR

Patent Attorney and Editor "The Technical Survey"

Foaming of Oils

DIFFICULTIES encountered with oil foaming are relatively new, since very few base mineral oils have a tendency to foam under ordinary operating conditions. However, with the advent of compounding agents such as the alcoholates, naphthenates, phenates and fatty acid soaps, foaming has become a serious problem. The dry sump lubricating system employed in many aircraft engines is a particularly pernicious source of foaming trouble when compounded lubricants are used.

U. S. Patent 2,430,857, issued to California Research Corporation (affiliated with Standard Oil of California) discloses that foaming of oils can be inhibited by incorporating in the oil a small amount of a compound having not less than about 15% by weight of oxygen and represented by the formula:

$$A(X)_a \text{ or } (OR)_b$$

where A is an aromatic nucleus; X is an oxygen-containing substituent; R is a hydrogen, alkyl, aryl, aralkyl, or cycloalkyl radical; a is a whole number, and b is zero or a whole number.

As examples, the following compounds have been found suitable: Benzaldehyde, saligenin, methyl salicylate, resorcinol monoacetate, benzoyl acetone, amyl salicylate, phenyl and naphthyl salicylates.

"Mix-Master" tests were carried out to show the effectiveness of these agents with oils compounded with calcium cetyl phosphate, calcium alkyl phenate, etc. One set of data is given in Table 1.

It will be observed that compounding increased foaming of the base oil from 11% to 57%. The best foam reduction was obtained with benzoyl acetone, which brought the foaming down to the level of the base oil.

TABLE 1—Effect of Foam Inhibitors in Compounded Lube Oils

	Per cent increase in foam volume at 275° F.
Uncompounded oil	11
Compounded oil	57
+0.1% benzaldehyde	29
+0.1% saligenin	17
+0.1% methyl salicylate	23
+0.1% resorcinol monoacetate	29
+0.1% benzoyl acetone	11
+0.1% amyl salicylate	47
+0.1% phenyl salicylate	29
+0.1% naphthyl salicylate	29

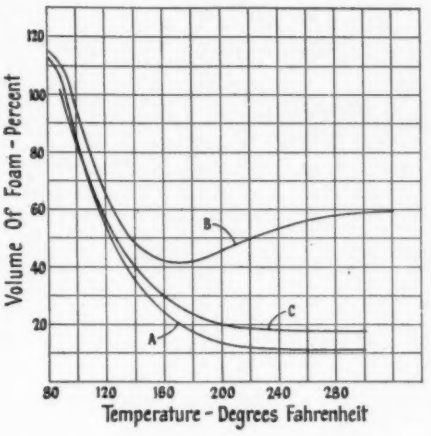

Fig. 1—How foaming is influenced by the addition of inhibiting oxygenated compounds. Curve A represents an uncompounded oil, curve B the same oil containing .25% by wt. of a 2:1 mixture of calcium alkyl phenate and calcium cetyl phosphate, and curve C the latter blend also containing .1% of saligenin. (U. S. 2,430,827)

Figure 1 shows graphically how foaming is influenced by the inhibiting oxygenated compounds. Curve A represents an uncompounded oil. Curve B represents the same oil containing 0.25% by wt. of a 2:1 mixture of calcium alkyl phenate and calcium cetyl phosphate, while Curve C represents the latter blend also containing 0.1% of saligenin. As is obvious from the graph, the compounding agent increases considerably the foaming tendency, whereas addition of the oxy compound reduces the tendency to almost that of the base oil.

As brought out in a previous article on the subject in this journal[1], the foam inhibiting action of defoamers appears to be connected with the insolubility or partial solubility of the defoamer in the oil. The introduction of oxygen into the molecule does reduce solubility in hydrocarbon oils, and advantage has been taken of this technique in the case of V.I. improvers and pour inhibitors[2]. Apparently the same characteristic must be present in antifreeze defoamers, since oils such as sec-butyl phosphate may not be completely soluble in aqueous alcohol[3].

Isobutylene

ONE CHEMICAL which is obtainable in pure form from petroleum and which is finding widening uses is isobutylene. Atlantic Refining Company finds that it can be produced in high concentration from polymer liquids consisting predominantly of isobutylene-butene codimers. A gas of about 95% isobutylene concentration is claimed to be obtained (in its U. S. Patent 2,390,951) by depolymerizing over an argillaceous catalyst. Apparently isomerization of butene to isobutylene also occurs during the process.

The liquid polymer is pyrolyzed at 400-800° F. over fuller's earth with rate of charge of liquid being 0.5-5.0 vols. of liquid polymer per vol. catalyst per hr. The spent catalyst may be regenerated by calcination, etc. A yield of at least 90% of isobutylene is obtained despite the fact that the codimers contain 50% of normal butene radicals.

Anhydrous Desulfurization of Gases

IN CATALYTIC reactions which require sulfur-free gaseous raw material, the presence of water may also be detrimental because of its poisoning effect upon the catalyst. Most desulfurizing methods tend to introduce water during treatment and are thus unsuitable in such cases.

In its U. S. Patent 2,430,982, Air Reduction Company describes a method for obtaining a dry, sulfur-free gas by scrubbing the sulfur-containing gas with an oil solution of copper naphthenate. Mercaptans and hydrogen sulfide are both removed by this means.

Figure 2 shows a diagrammatic flowsheet of the process. A solution (1-10%) of copper naphthenate in gas oil is sprayed from storage tank 8 into tower 5 through nozzle 6 countercurrent to the sulfur-containing gas entering the tower through pipe 11. The mercaptans react to form copper mercaptide which is precipitated as a finely divided solid

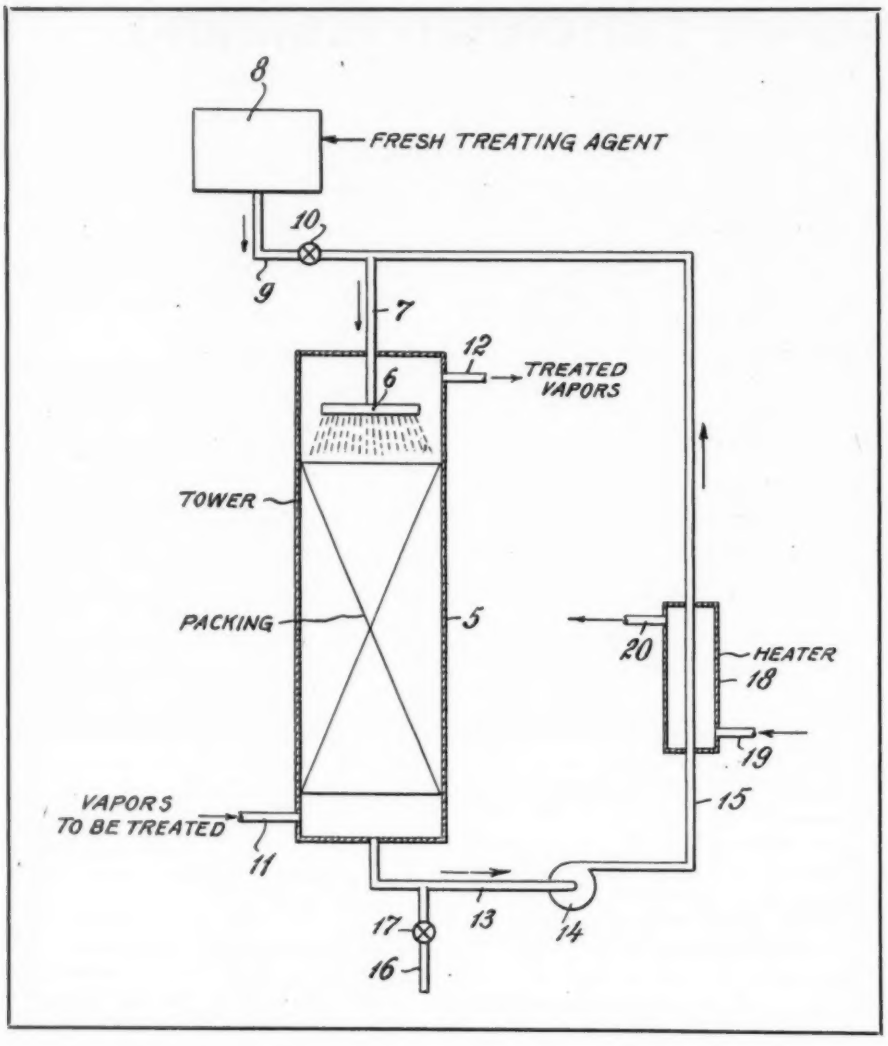

Fig. 2—Flow chart for Air Reduction Co. process of producing a dry, sulfur-free gas by scrubbing with an oil solution of copper naphthenate. (U. S. 2,430,982)

which remains in suspension in the oil. The reaction with disulfides is apparently more complex, but they are claimed to be converted to stable, non-volatile compounds and are thus removed from the gas.

References

(1) Gaylor, *Nat.Petr.News* 7/4/45 p.R-504.

(2) U.S. 2,123,641 (S.O.D.).

(3) *Nat.Petr.News* 11/7/45 p.R-909 (U.S. 2,382,698).

Selected Patents of the Month

U.S. 2,429,319 (Stand. Oil Dev.)—Easily pulverized xero-gel.

U.S. 2,429,359 (Universal Oil Products)—Catalytic conversion.

U.S. 2,429,373 (Universal Oil Products)—2,2,3-Trimethyl butane (triptane) from 2,3 dimethyl butene and chloromethyl methyl ether.

U.S. 2,429,474 (A. D. Little, Inc.)—Apparatus for determining vapor content of a gas.

U.S. 2,429,479 (Stand. Oil Dev.)—Pour inhibited lube oil.

U.S. 2,429,484 (Shell Dev.)—Purifying ketones and ketols.

U.S. 2,429,501 (Shell Dev.)—Cyclopentane carboxaldehyde from cyclohexene.

U.S. 2,429,565 (Socony Vacuum) — Reaction products of hexamethylenetetramine and petroleum wax substituted oxyaromatic compounds having rubber-like properties.

U.S. 2,429,566 (Rice)—Cracking olefines.

U.S. 2,429,575 (Shell Dev.) — Synthesis of branched chain hydrocarbons from heterocyclics.

U.S. 2,429,582 (Shell Dev.) — Polymers of branched chain hexadienes.

U.S. 2,429,205 (M. W. Kellogg Co). — Alkylation.

U.S. 2,429,218 (Phillips Petr.)—Isomerization.

U.S. 2,429,232 (Phillips Petr.)—Supported $AlCl_3$ catalyst.

U.S. 2,429,247 (Foster Wheeler)—Fluid catalytic conversion.

U.S. 2,429,980 (Lion Oil)—Conducting chemical reactions in presence of small size solids.

U.S. 2,429,981 (Houdry Process) — Conversion of hydrocarbons with alkali metal-free catalyst.

U.S. 2,430,015 (Shell Dev.)—Utilization of powdered catalysts.

U.S. 2,430,050 (Gill) — Preventing mercaptan oxidation and odor fading by inhibiting with phenol.

U.S. 2,430,212 (Texas Co.)—Alkylation of ethylene.

U.S. 2,430,245 (Socony)—Catalytic operation.

U.S. 2,430,255 (Calif. Res. Corp.)—Alkali metal selenides.

U.S. 2,430,269 (Pure Oil)—Mercaptan extraction.

U.S. 2,430,388 (Phillips Petr.)—Ethers.

U.S. 2,430,416 (Ketarome Ltd.) — Aromatization of coal carbonization oils.

U.S. 2,430,430 (Socony)—Synthesis gas.

U.S. 2,430,443 (Standard Oil Ind.)—Olefin oxides.

U.S. 2,430,546 (Texas Co.)—Bituminous coating composition containing oil soluble amine.

U.S. 2,430,632 (Shell Dev.)—Tungsten sulfide catalyst.

U.S. 2,430,660-1 (Phillips Petr.)—Alkenyl aromatics.

U.S. 2,430,724 (Socony)—Catalytic conversion.

U.S. 2,430,803 (Atlantic Refg.)—Sulfuric acid-silica gel catalyst.

U.S. 2,430,815 (Atlantic Refg.)—Increasing adhesivity of bitumens with Al petroleum sulfonates.

U.S. 2,430,821 (Shell Dev.)—Unsaturated 3-sulfolanylamines.

U.S. 2,430,842 (Atlantic Refg.)—Synthetic lubricant.

U.S. 2,430,846 (Cities Service) — Protective coating for metals.

U.S. 2,430,857-8 (Calif. Research)—Foam inhibited oil.

U.S. 2,430,864-5 (Union Oil)—Hydrocarbon peroxides.

U.S. 2,430,951 (Standard Oil Ind.)—Corrosion-inhibited turbine oil.

U.S. 2,430,979 (Stand. Oil Dev.) — Isomerization.

U.S. 2,430,822 (Atlantic Refining)—Chlorinating isopropylbenzenes.

U.S. 2,430,993 (Stand. Oil Dev.)—Plasticizing polyisobutylene with benzoil peroxide.

U.S. 2,430,998 (Stand. Oil Dev.)—Asphalt.

U.S. 2,432,008 (Stand. Oil Dev.) — Grinding coolant.

U.S. 2,431,010 (Stand. Oil Dev.)—Soluble cutting oil.

U.S. 2,431,011 (Stand. Oil Dev.)—E p lubricant.

U.S. 2,431,143 (Lummus Co.) — Fibrous catalyst system.

U.S. 2,431,216 (Phillips Petroleum) — 2-Vinyl furan from 2-furan acrylic acid.

U.S. 2,431,224 (Shell Dev.)—Polyallyl alcohol.

U.S. 2,431,243 (Shell Dev.)—Catalytic cracking.

U.S. 2,431,322 (Calif. Research)—Alkyl ether Diesel engine starting fluid.

U.S. 2,431,403 (Sun Oil)—Polymerizing butadiene with alumina.

U.S. 2,431,427 (Phillips Petr.)—Alumina base dehydrogenation catalyst.

U.S. 2,431,453 (Stand. Oil Dev.)—Continuous grease manufacture.

U.S. 2,431,481 (Rohm & Haas)—Stable, gelling, acidic hydrous silicates.

U.S. 2,431,515 (Stand. Oil Dev.) — Aromatic aviation gasoline.

U.S. 2,431,630 (Stand. Oil Ind.)—Catalyst regeneration.

U.S. 2,431,655 (Dow Chem.)—Decolorizing aromatic hydrocarbons.

U.S. 2,431,715 (Shell Dev.)—Preventing HF corrosion.

U.S. 2,431,737 (Nopco Chem.) — Noncorrosive lubricant.

U.S. 2,431,754 (Universal Oil Products)—Dehydrating ketones.

U.S. 2,431,755 (Universal Oil Products)—Isomerizing cyclo olefins.

U.S. 2,431,756 (Universal Oil Products)—Aromatics from terpenes.

U.S. 2,431,760 (Nopco Chem.)—Aluminum base greases.

U.S. 2,431,857 (Texas Co.)—Operating internal combustion engines.

U.S. 2,431,899 (Texas Co.)—Photronic cell circuit.

U.S. 2,432,087 (Stand. Oil Dev.)—Xylidene.

U.S. 2,432,099 (Stand. Oil Dev.) — Aromatic amines.

U.S. 2,432,109 (Zisman et al)—Break-in fuel containing alkyl silicate.

U.S. 2,432,277 (Shell Dev.)—Catalytic cracking.

U.S. 2,432,286 (Calif. Res.) — Coprecipitated alumina-molybdena catalyst.

U.S. 2,432,301 (Shell Dev.)—Converting hydrosulfides into neutral S compounds.

U.S. 2,432,423 (Imperial Chemical Industries) —Purification and compression of ethylene.

U.S. 2,432,440 (Texas Co.)—Oxidation-resistant sulfurized turbine oil.

U.S. 2,432,458 (Sun Oil)—Diolefin recovery.

U.S. 2,432,520 & 872-3 (Phillips Petr.)—Pebble heater.

U.S. 2,432,746 (Filtrol Corp.)—Catalytic cracking.

U.S. 2,432,771 (Union Oil)— Hydrocarbon separation by azeotropic distillation with trioxane.

U.S. 2,432,829-40 (Shell Dev.)—Nitrite salts of primary amines as corrosion inhibitors.

U.S. 2,432,991 (Socony-Vacuum)—Acylation of thiophene.

U.S. 2,433,008 (Gulf Res. & Dev.)—4,6-Ditertiary butyl-3-methylcyclohexanol.

U.S. 2,433,020 (Stand. Oil Ind.)—Alkylating aromatics with paraffins.

U.S. 2,433,045 (Carbide)—Gas phase polymerization of olefins to solid polymers.

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Standing loss per year	1,600 bbls.	120 bbls.
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Total annual evaporation loss ..	3,136 bbls.	120 bbls.
Net annual savings		3,016 bbls.

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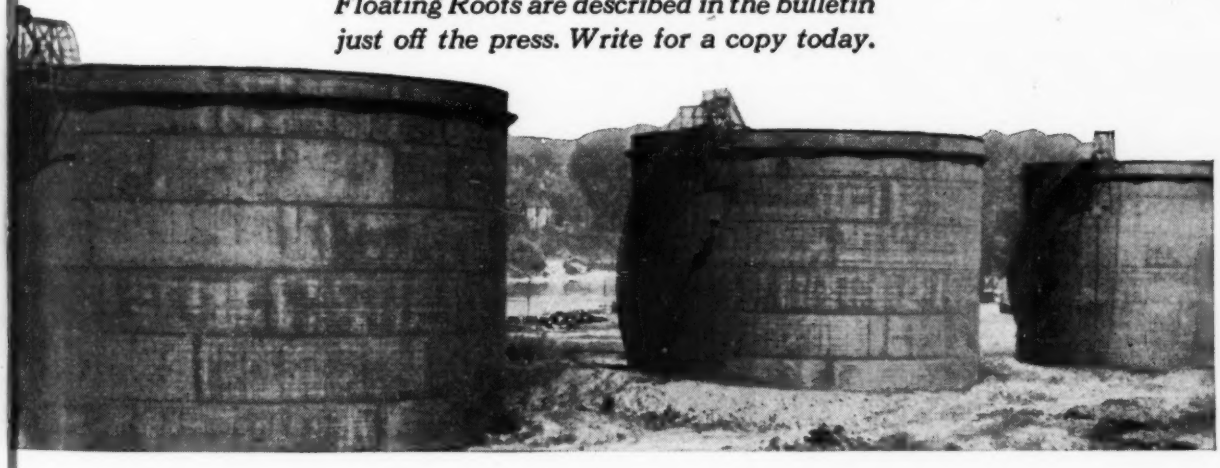

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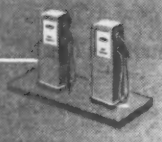

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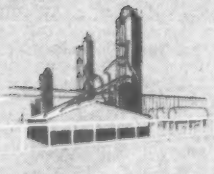

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Catalysis Heat Losses Kept Low By Means of Electronic Device

In addition to the electronic heating device for reducing catalysis heat losses described below, this month's review of new and improved devices used in petroleum processing and handling operations on which patents have recently been issued includes:

- **Bourdon tube replaces needle in small flow control valve**
- **Measure oil gravity rapidly in "floating" pipeline loop**
- **Troublesome valves indicated on cycle-timed process units**
- **Railway car-mover operated by geared-up electric motor**

ELECTRONIC, OR HIGH frequency electric heating can be used in the catalytic reaction of hydrocarbons because it induces heat throughout the body of the catalyst and not just at the surface. As a result, heat losses are kept low, it is claimed.

Sectional views of a catalytic reactor employing electronic heating are shown in Figs. 1 and 2. Catalyst enters through line 1 and flows by gravity through the annular spaces 6, 7, 8, 9, and 10 provided by the concentric shells 31, 32, 34, 35, and 36. Reactant gases enter at line 22, flow countercurrently to the catalyst, and leave via line 23.

The shells are supported structurally on insulators 37 mounted on the insulated spider 2A. Lead-in connections from the source of high frequency current, G, are secured to center electrode 30 and to shells 31 and 32. Shells 34, 35, and 36 serve as grounded electrodes. Equal distances between the shells insure a uniform potential gradient in all reaction zones.

The voltage which may be used can be up to 15,000 volts per in.; the frequency may vary from 1 to 25 megacycles. The higher ranges are more desirable because the lowest potential gradients are required.

It is stated that the process should find utilization in cracking, dehydrogenation, destructive dehydrogenation, isomerization, alkylation, and other catalytic reactions involving vapors, gases, or liquids, and catalysts of high dielectric constants.

Preferred catalyst particle size is 4 to 10 mesh, in pellet form, about 1/16 to 3/16 in. in diameter and higher. The reactor was designed for use in a moving bed process, but the technique can be applied to fixed bed or "fluid" processes, it is said.

U. S. 2,432,934, issued Dec. 16, 1947, to John P. Rasor, assignor to Filtrol Corp., Los Angeles.

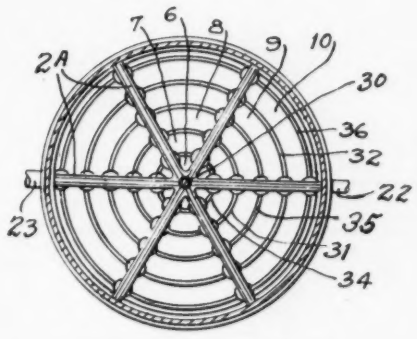

Fig. 2—Plan view of reactor shown in Fig. 1, showing insulating spider

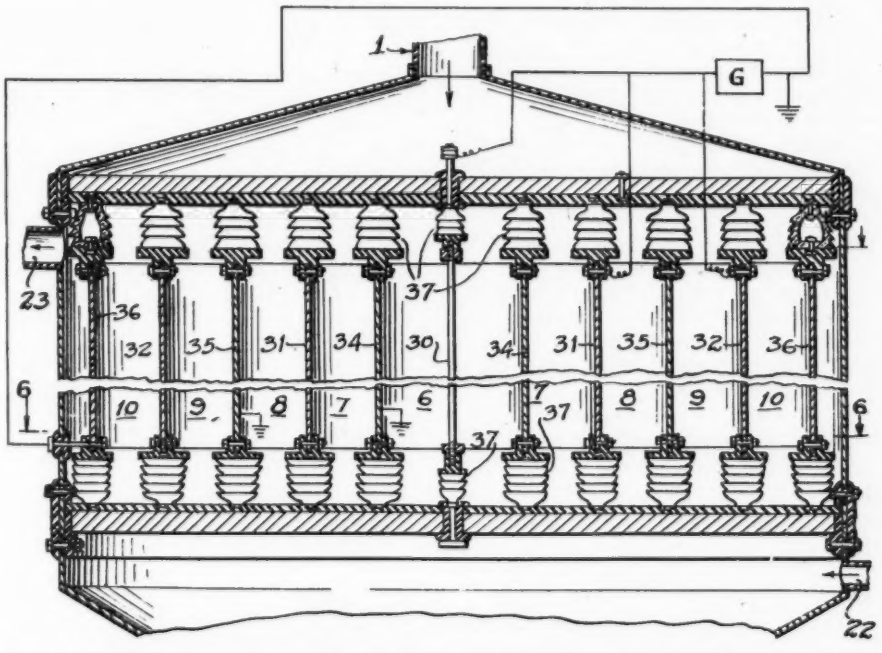

Fig. 1—High frequency electric current passing through this catalytic reactor heats catalyst from "inside out" and not only its surface (U. S. 2,432,934)

Bourdon Tube Replaces Needle In Small Flow Control Valve

DISADVANTAGES ENCOUNTERED when using conventional needle valves for obtaining a small, adjustable flow of gas or liquid are said to be eliminated by the use of a Bourdon tube.

Objections to needle valves for automatic controlling are that stuffing glands may leak, valves may become clogged with dust, and they are not easily nor accurately calibrated. The principle of the Bourdon valve is a mechanism which changes the bend in the tubing, thereby varying its internal cross-sectional area and providing variable restriction to the flow of fluid.

An advantage of the Bourdon tube is that it will give a straight-line relationship between change of restrictor setting to change of flow. It was found that, as the degree of bending of the tube is changed from one step to another, the flow through the tube is changed in equal percentage steps.

The controller is shown in Figs. 3 and 4. Fluid enters via line 14, passes through round tube 17 to passageway 21 in the movable block 20, returns through flat tube 22, and out via line 25.

The degree of bending is effected

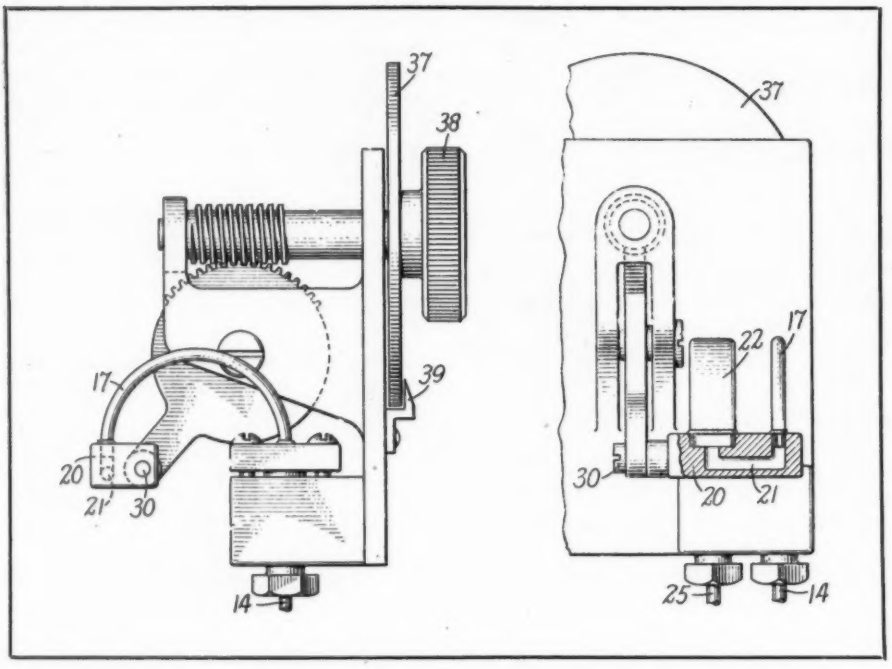

Fig. 3—Side view of Bourdon tube variable resistance valve (U. S. 2,432,082)

Fig. 4—Partially sectional front view of Bourdon tube variable resistance valve

by end block 20, pivotally-mounted to arm 30 of the worm and pinion assembly which is controlled by knob 38, dial 37, and pointer 39.

U. S. 2,432,082, issued December 9, 1947, to Gerald I. Bilyeu, assignor to The Foxboro Co., Foxboro, Mass.

Measure Oil Gravity Rapidly In "Floating" Pipeline Loop

SPECIFIC GRAVITY of oil flowing through a pipeline can be measured instantaneously, or without an appreciable time lag, in the device shown in Fig. 5. The system is said to operate regardless of conditions of pressure or temperature of the fluid, or turbulence or velocity rates, and it can be used equally well on refinery lines, cross-country lines, or in the oil fields.

Pipe 10 may be an integral part of the main line or a valve-controlled by-pass. It should be as flexible as possible and not heavier than required by the pressures involved. It is encased, for protection, in larger diameter pipe 13 and in housing 17. It is rigidly attached by welding at 11 and 11a to the flanged heads 12 and 12a.

The curved end 19, free to swing in the vertical plane, is connected to an indicator 39 by means of links to yoke 33 at the apex of the loop. End 19 is supported on float 27 submerged in trough 29. Float 27 includes an outlet 35 for adjusting its buoyancy by putting in or taking out liquid ballast 28, thus providing means for calibration.

Deflections at indicator 39 are therefore effected by varying weights of fluid in line 10 causing end 19 to swing up and down. Using a 2-in. diameter pipe for line 10, tests showed the sensitivity of the instrument to be at about the fourth decimal place, it is said.

U. S. 2,432,039, issued Dec. 2, 1947, to Norris Plank, assignor to Shell Development Co., San Francisco.

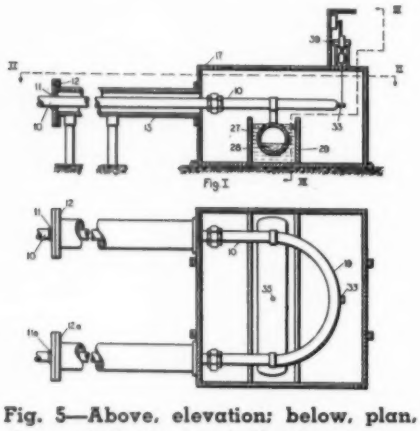

Fig. 5—Above, elevation; below, plan, views of device for indicating instantaneously the specific gravity of fluid flowing through a line (U. S. 2,432,039)

Troublesome Valves Indicated On Cycle-Timed Process Units

OPERATION OF FIXED bed catalytic reaction units depends upon the proper functioning of the many control valves. A newly-patented device, tied in with the cycle timer, will indicate the condition of valve operation at the control panel. In this way, the operator of the unit will know of any trouble and be able to correct it immediately.

In the normal operation of such control valves, a system is provided for admitting steam at a known temperature, pressure, and rate of flow to the valve seat. The purpose is to block, or prevent the intermingling of, fluids on either side of the valve gate.

In the event the gate does not seat properly, the amount of steam sent to any particular valve will naturally be greater. Any change of this nature can be detected by a thermocouple, differential pressure switch, or the like, installed in the line to each valve seat. The detected change is then transmitted to the main control panel at the same time that the cycle timer is indicating which valve should be operating.

U. S. 2,430,122, issued November 4, 1947, to Edward J. Grace, Jr., assignor to Sun Oil Co., Philadelphia.

Railway Car-Mover Operated By Geared-Up Electric Motor

FEWER STRAINED backs can be expected through use of an electrically-powered railway car-moving apparatus recently patented, similar to the manual type of car-mover.

In essence, the device operates on the same principle as the conventional manual tool. It fits under the car wheel, and bracing itself on the rail pushes against the wheel, propelling the car slowly forward. It is shown in Fig. 6.

The upper end of the handle 18 contains a small toggle switch 28A for actuating small electric motor 20, which operates through a gear box reducer to obtain the necessary power and leverage. The motor also is geared so as to propel the tool itself along the rail, keeping it in contact with the car wheel.

U. S. 2,432,156, issued Dec. 9, 1947, to Robert H. Hill, Elgin, Ill.

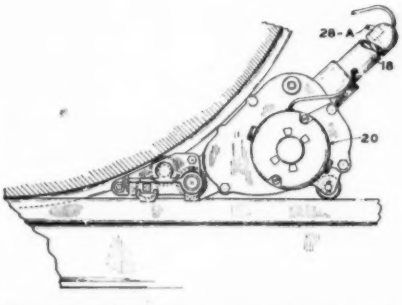

Fig. 6—Railway car-mover is operated by geared-up electric motor, saving possible strained backs (U. S. 2,432,156)

how to meet a big demand...

with your own brand!

RIGHT NOW! . . . there's a big market among motorists, truckers and farmers for a *good* gum solvent . . . an "upper lubricant" additive for gasolines that helps reduce valve sticking and wear, gives more power to sluggish motors!

AND RIGHT NOW! . . . you can get your share of this big and profitable market with PARADYNE Fuel Improver. It's rolling up profits for oil companies and auto accessory distributors . . . *and it's available for repackaging under your own brand name!* Write for Bulletin 101 and further details.

READ WHAT A MOTORIST WRITES ABOUT PARADYNE FUEL IMPROVER:

"I mixed Paradyne Fuel Improver with the gasoline in my '41 Buick (mileage: 76,000 — new rings installed at 30,000 mi.) and immediately noticed a decided improvement in its pick-up and pulling power on hills. The valves became freer and seemed to seat better. The motor also ran more smoothly and idled without missing."

Valve at right stuck in engine run on high gum content gasoline without solvent additive. Valve at left is from same engine, using same fuel—with Paradyne Fuel Improver added. It operated over three times as long and was still running free.

PARAMINS*

make good motor oils and fuels better!

ADDITIVES WITH A BACKGROUND

PARAMINS ADDITIVES ARE KNOWN BY THE BRANDS:

PARATONE —*for improved viscosity index.*
PARAFLOW —*for lower stable pour.*
PARATAC —*for tacky oils and greases.*
PARAPOID —*for E.P. gear oils.*
PARANOX —*for inhibiting corrosion and oxidation.*
PARASHEEN —*for better appearance.*
PARADYNE —*for improved gasoline.*

*Trade Mark

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Overnight, your office chair becomes "A SEAT IN CONGRESS"

Something may happen in Washington today . . . something which may directly affect your business.

The question is: *When will you know about it?*

December 18th was such a day. Senator Tobey's committee had been striving for a solution to the heating oil shortages along the East Coast. An oil industry advisory group had submitted a plan of voluntary action. Without delay, the committee had added its stamp of approval.

Too bad that every oil industry executive could not have been there in person. But, thousands of them knew that a certain envelope would bring a complete report to them on the following morning —the envelope which daily brings Platt's OILGRAM NEWS.

On the spot and ready for action on that important day was the Washington staff of OILGRAM NEWS. Quickly and accurately, the report was put into condensed form. Teletypes sped the story to New York, Cleveland and Tulsa, three cities in which "the little newspaper with the big news" is simultaneously printed and rushed into distribution.

Next morning, the facts were on the desks of all subscribers in sufficient detail that many proposed activities actually could be started. Then, the following day's edition carried complete text of the plan for those who wanted to study it word for word.

Wherever oil news is made, or oil prices are quoted, the staff of Platt's OILGRAM NEWS is on hand *every day* to speed the facts to you. That is why this service, overnight, makes your desk a meeting place for the best brains of the industry—or your office chair *"a seat in Congress".*

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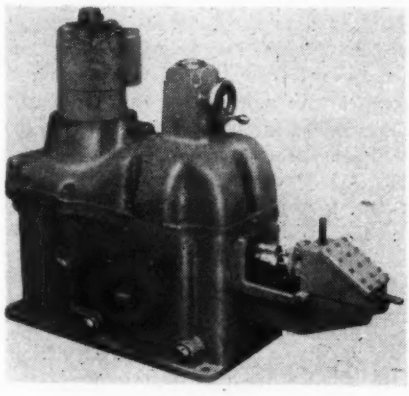
FOR MORE INFORMATION, use one of these reply cards to request additional details or literature on any items reviewed in "What's New!" Just circle the numbers corresponding to the numbers on the items you're interested in, fill in the bottom of the card, and drop it in the mail. No postage needed.

What's New!

Edited by WILLIAM C. UHL, Equipment Editor

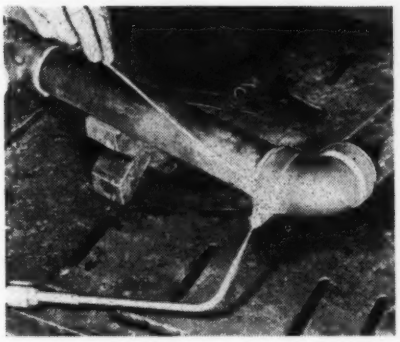
1—Precise Volume Control

The "Constametric" Pump is a new piston-type pump developed to handle liquids in precisely controlled volume to deliver at a constant rate without pulsation, and to pump in minute quantities, as low as 75 ml/hr. Pump utilizes step valve design for a total of eight check valves to maintain discharge volume at constant rate. Capacity is adjustable while pump is operating through use of hand micro controller on top of casing. Capacity ratings range from 75 ml./hr. to 34.2 gals./hr., and maximum operating pressures from 15,000 to 650 psi. Available in stainless and nickel alloys. Milton Roy Co.



2—Threadless Fittings

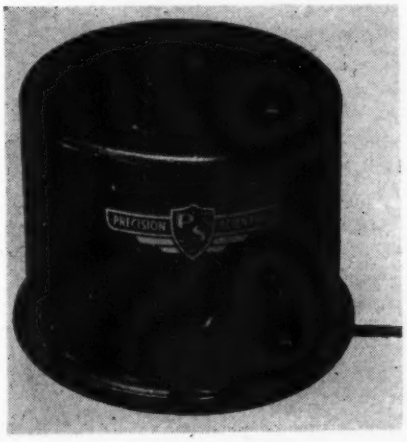
Silver alloy brazing has been adapted for use in the new Flagg-Flow line of threadless malleable pipe fittings in sizes through two inch, and for standard black steel or wrought iron pipe. They are said to be applicable wherever 150 psi., standard weight screwed fittings are employed; for 150 psi. working steam pressure at 450° F., or 300 psi., non-shock, oil, water, or gas lines at 150° F. Specific applications suggested are meter and instrument lines, boiler feed lines, gas and air piping, and hydraulic systems not over 300 psi. The fittings eliminate reduction in wall thickness ordinarily encountered in threaded joints, and are designed



for smooth fluid flow channels. They enable pipe layouts in tight places because they do not require wrench space. Stanley G. Flagg & Co., Inc.

3—Magnetic Stirrers

Recommended for use in agitating laboratory liquids under pressure, in a vacuum, or in a closed system are two new magnetic stirrers. One is operated electrically and called "Magne-Mix"; the other is operated by air and called "Aero-Magne-Mix". The motor has sufficient torque to vigorously stir an 80% glycerol solution and can be used on large or small quantities of solutions. Both stirrers utilize a rotating magnetic field to induce variable speed stirrer action. The air-operated model is suggested for use wherever explosive vapors or flammable liquids are present. Precision Scientific Co.



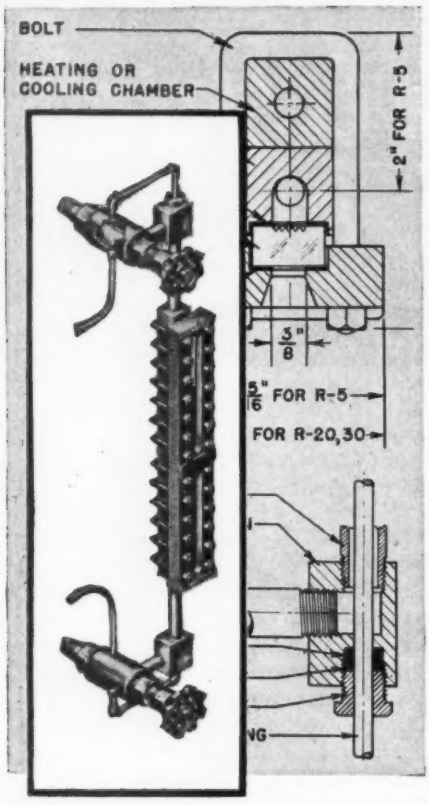
4—Emergency Air Mask

Using pure compressed air, the Senior Sling-Pak, Model 6000-B4 Breathing Apparatus is reported to be advantageous in fighting fires in and around concentrations of petroleum vapors. When charged to the required pressure of 1980 psi., it provides a minimum of 15 minutes at extreme exertion; 20 to 25 minutes at normal exertion; and 25 to 35 minutes maximum duration. The air cylinder, 18½ in. long by 5¼ in. diameter, is worn across the back. The unit weighs 19½ lbs. complete, and permits entry through small manholes or doors. Scott Aviation Corp., Safety Equipment Division.

5—First Aid for Burns

A line of three first aid kits for emergency treatment of burns has been placed on the market. The Burn Spray Kit includes a spray gun and five 4-oz. bottles of Foille emulsion, an emergency dressing. Two Fire Department Kits are also available. One contains 36 selected dressing units, the other 24 units. All three kits are in carrying cases of 20-gage steel, moisture and dust proof, with handles and brackets for wall mounting, and painted red for quick identification. An instruction sheet is placed inside the cover of the kit. The Medical Supply Co.

More "What's New!" Items, Page 170



JERGUSON HEATED AND COOLED GAGES

Give Accurate Readings Under All Conditions

USE Jerguson Heated Gages for accuracy if you are dealing with high viscosity liquids that flow sluggishly.

On the other hand, if you are dealing with highly volatile liquids which tend to boil, use Jerguson Cooled Gages with circulating cooling medium.

In either case, Jerguson engineers have the answer, with a complete line of gages that give accurate reading of *all* liquids under *all* temperature conditions.

Jerguson Heated-Cooled Gages are made in internal tube and double chamber models for all pressures.

Illustration shows Internal Tube Model, Reflex Type, with No. 93 Valves. Write for Data Unit No. 17.

JERGUSON
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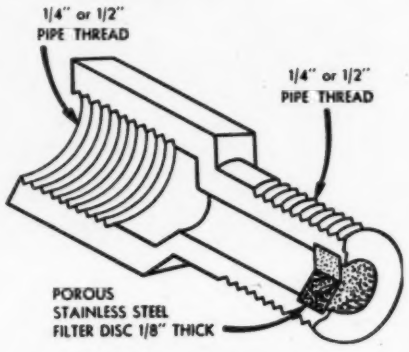
6—Pressure Snubber

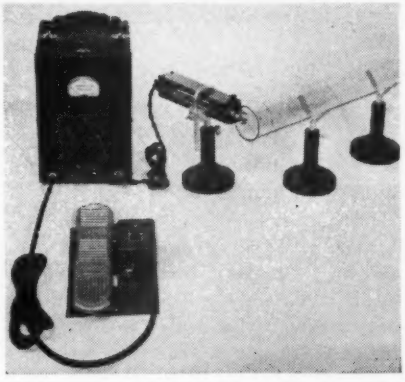


A porous stainless steel filter disc has been incorporated into the new Equipoise Snubber, which is designed to eliminate pressure gage fluctuation caused by pressure pulsation and vibration. By smoothing out pressures, the device allows the gage to indicate steady average pressure and protect the indicator mechanism against undue shock and wear. The filter prevents clog-up. Specially designed filter discs are available for air, oil, water, mercury, etc. Maximum differential pressure rating of the standard types is 500 psi. Snubbers for use up to 5000 psi. differential can be supplied. Equipoise Controls, Inc.

7—Fire Extinguisher

The "All-Out" Fire Extinguisher, 10-lb-unit, is said to cover a fire area with dry chemical up to a distance of 18 ft. Measuring 17 in. high by 7-1/2 in. diameter, the unit weighs 26-1/2 lbs. and carries a cartridge containing 10 lbs. of carbon dioxide to discharge the powder. Main cylinder contains dry chemical and has been tested to 1400 psi. The highest pressure attained by discharging an overcharge of CO_2 into the large chamber packed with powder and under closed nozzle and elevated temperature conditions is reported to be 405 psi. All-Out Mfg. Co.

8—Glass Tubing Cutter

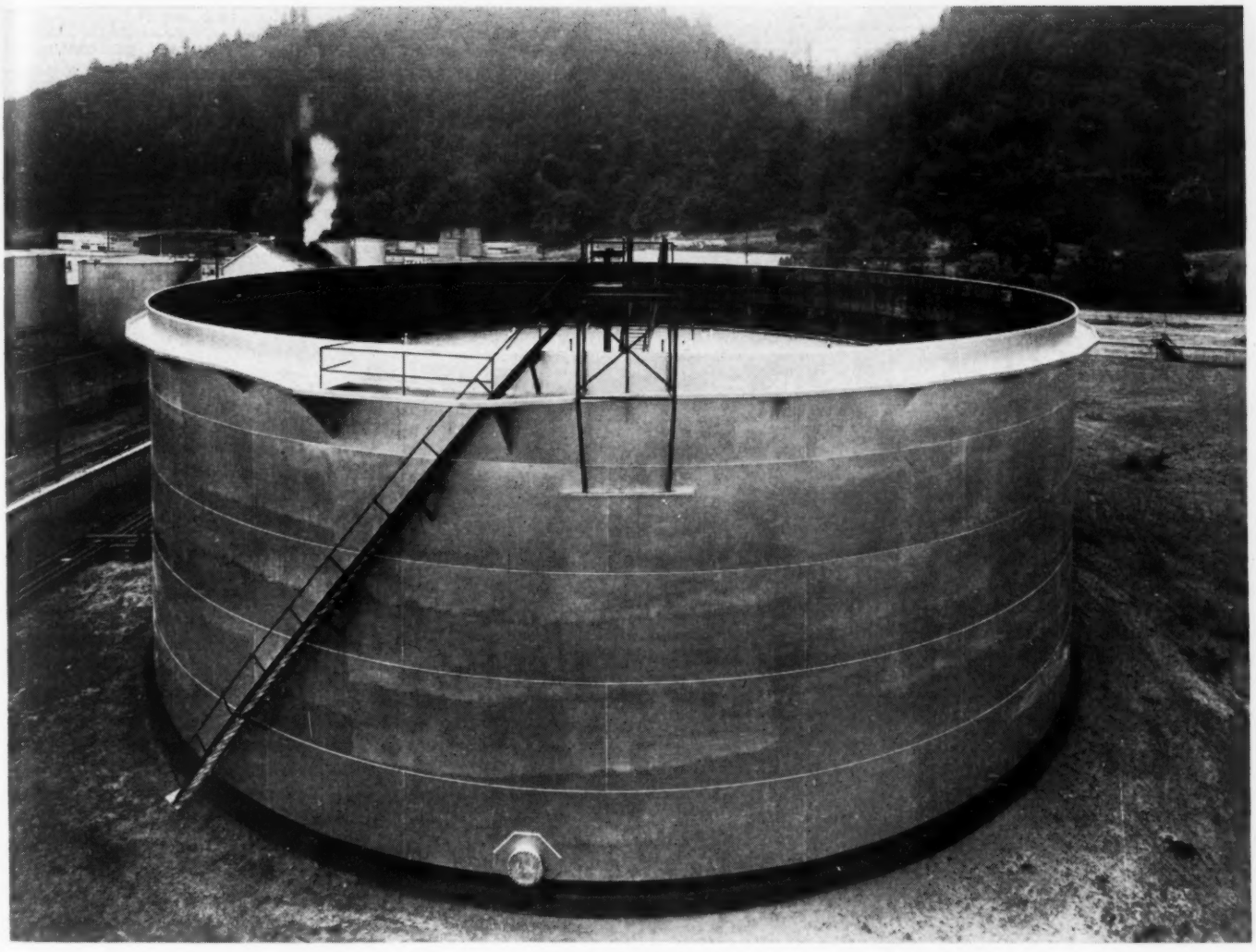


The familiar, hot-wire principle for cutting glass tubing has been adapted in the design of the new Even Heat Glass Tubing Cutter. With the tool, tubing up to 7½ in. outside diameter can be cut in any position, as a separate piece or as an integral part of apparatus already set up. Adjustable supports are provided for use when individual pieces are to be cut, but the device can be detached for manual operation using a foot switch to free both hands of the operator. Eberbach & Son Co.

9—Hand Centrifuge

Using a 24-1 gear ratio, a new heavy duty hand power laboratory centrifuge is said to allow reduced crank speed. Capacity of the unit is two or four 100 cc. tubes. Outer diameter of swing is 16 inches. Entire centrifuge can be stowed in the stationary guard bowl when not in use. The Gerin Corp.

More "What's New!" Items, Page 172



THE HORTON DOUBLE-DECK FLOATING ROOF

. . . reduces evaporation losses
. . . helps maintain the physical properties of the product stored

Horton Double-Deck Floating Roofs perform two important functions for the petroleum industry. First, they eliminate all filling losses and reduce breathing losses that normally occur when a volatile petroleum product is stored in a fixed-roof tank. Second, they help to maintain the quality of the product stored.

The Horton Dougle-Deck Floating Roof is used on flat-bottom tanks storing crude oil, gasoline and other petroleum products. It is particularly recommended for tanks that are filled or emptied more than six times a year, tanks in blending service and tanks containing sour crude oil.

The above photo shows a 120-ft. diam. by 40-ft. flat-bottom gasoline storage tank with a Horton Double-Deck Floating Roof. It holds 80,000 bbls.

The table below shows a comparison of the evaporation losses which normally take place in an 80,000-bbl. cone-roof tank and an 80,000-bbl. flat-bottom tank with a Horton Double-Deck Floating Roof. The losses are based on a 10-lb. Reid vapor pressure gasoline at 56° F. The fixed roof tank averages 1/3 full.

Capacity of Tank	EVAPORATION LOSS IN BARRELS OF 42 U.S. GALLONS			
	GAS TIGHT CONE ROOF		HORTON DOUBLE-DECK FLOATING ROOF	
	Annual Breathing	One Filling	Annual Breathing	One Filling
80,000	1700	120	180	0

CHICAGO BRIDGE & IRON COMPANY

Plants in BIRMINGHAM, CHICAGO and GREENVILLE, PENNSYLVANIA

Chicago, 4.....2114 McCormick Bldg.
New York, 6.....3310-165 Broadway Bldg.
Cleveland, 15.....2215 Guildhall Bldg.
Los Angeles, 14.....1426 Wm. Fox Bldg.
Atlanta, 3.....2103 Healey Bldg.
Birmingham, 1.....1527 North 50th St.
Tulsa, 3.....1620 Hunt Bldg.
Houston, 2.....2130 National Standard Bldg.
Philadelphia, 3..1630-1700 Walnut Street Bldg.
Havana.....402 Abreu Bldg.
San Francisco, 11..1208-22 Battery Street Bldg.
Detroit, 26.....1532 Lafayette Bldg.

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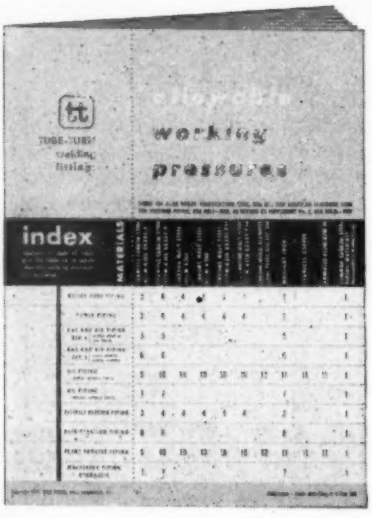
Chicago Bridge & Iron Company, Limited, Apartado 1348, Caracas, Venezuela
Ateliers et Chantiers de la Seine Maritime, Paris, France
Constructions Metalliques de Provence, Arles-sur-Rhone, France
Leopoldo Sol & Cia., Reconquista 558, Buenos Aires, Argentina
Horton Steel Works, Limited, Fort Erie, Ontario, Canada
Whessoe, Limited, Darlington, England
Motherwell Bridge & Engineering Company, Limited, Motherwell, Scotland

HOW STRONG?

is a

Welding Fitting



GET THIS BOOK

Allowable Working Pressures: This book of pressure tables is a real working tool. Covers Tube-Turn welding fittings in all sizes, all weights, and all regularly manufactured materials, for Power, Oil and Chemical Process, District Heating, Gas, Refrigeration, and Hydraulic Piping. Mail the coupon.

TUBE-TURN

TUBE-TURN—*T. M. Reg. U. S. Pat. Off.*

WELDING FITTINGS AND FLANGES

District Offices at New York, Philadelphia, Pittsburgh, Detroit, Chicago, Houston, Tulsa, San Francisco, Los Angeles

Tube Turns, Inc., Dept. 3704, Louisville 1, Kentucky

Please send "Allowable Working Pressures" book.

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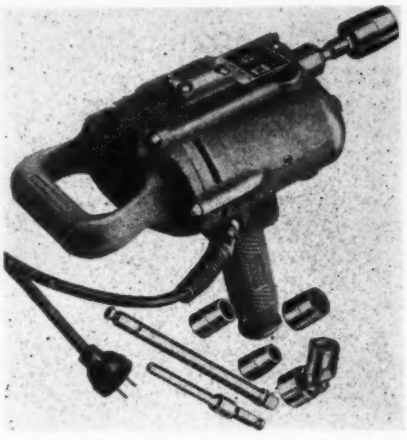
Street.....

City.....*Zone*....*State*.....

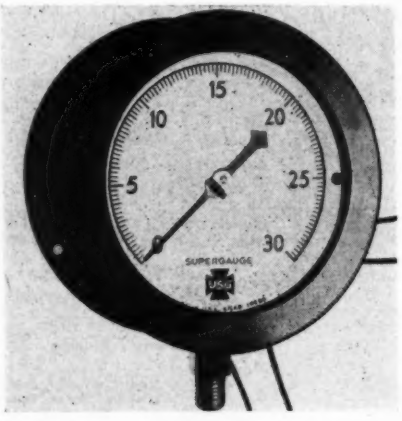
10—Impact Nut Setter



For rapid tightening or loosening of small nuts and bolts, up to ¾ in. size, the Speed-o-matic Nut Setter is a portable electric impact tool which is torqueless. It will not twist in an operator's hands when the nut becomes tight. It drives the nut or bolt at 1750 rpm at free speed. At the point of resistance, it automatically delivers 3000 impact blows per minute. Equipped with 25 ft. of rubber covered cord and plug with ground wire, it operates on any 110 volt, 60 cycle, AC or DC circuit. The tool has an overall length of 12½ in. and weighs 13½ lbs. Illinois Gage & Mfg. Corp.

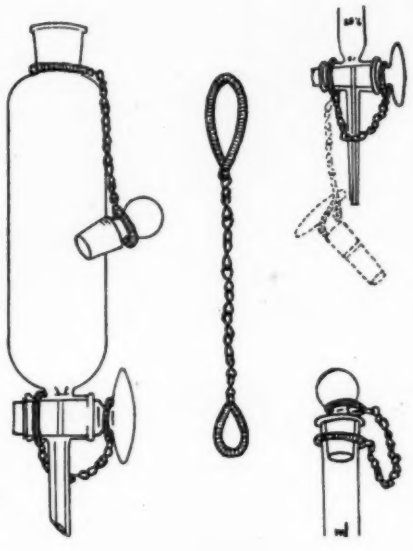
11—Pressure Switch

Two new pressure switches, types V and VI, feature a switching differential of 3% of the full scale and have an electrical capacity of 10 amps. at 125 volts, AC. This differential and capacity is available over the entire range from 30 in. Hg. vacuum to 10,000 psi. Both instruments are of similar functional design, but the type VI has an extra Bourdon spring connected internally to the alarm spring to activate a conventional type indicator. This is said to permit an accurate indication of the pressure being controlled while remaining independent of the setting of the electrical contacts. Both Type V and VI are suitable for measuring either temperature or pressure and can be had in a wide range of sizes and pressures. American Machine & Metals, Inc., U. S. Gauge Div.



12—Stopcock Leash

Losing or misplacing glass stoppers and stopcock plugs in the laboratory can be eliminated by the use of Stainless Steel Leashes for Laboratory Glassware. The device consists of two loops of metal spring and a length of small chain connecting them, and it is used as illustrated. Leashes are furnished in four sizes to fit most glass equipment. Metal Products Co.

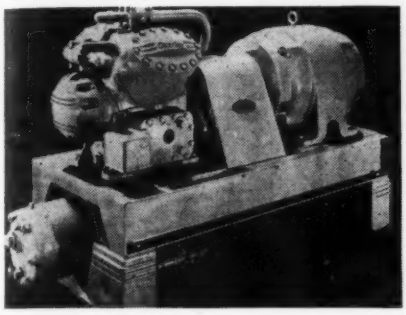


13—Tank Protection

A new coating material, "Coro-Gard", will prevent the corrosion of steel tanks in sour crude service for at least two years, according to the manufacturer. Coro-Gard has a synthetic resin base, a powdered mica gray pigmentation, and a solvent consisting of methyl-isobutyl-ketone and butyl acetate, 1:1 by volume. A black variation is achieved by added 2% carbon black. It can be applied to inside tank walls, floor, and roof by spray, brush, or slosh. Application requires 48 to 96 hours for an average tank, including cleaning, three coats, and curing. In tests, it has been shown to be effective against the action of sour crudes, salt water, and acidic salt solutions. Minnesota Mining & Manufacturing Co.

What's New!

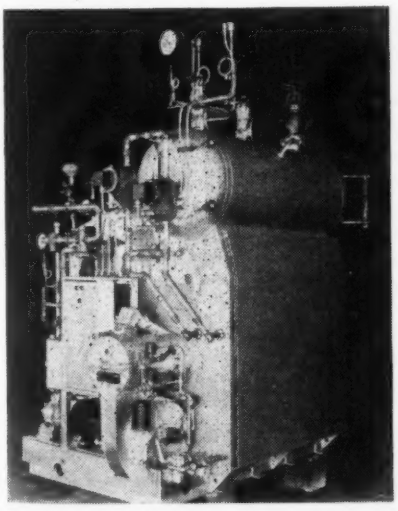
14—"Customized" Compressors



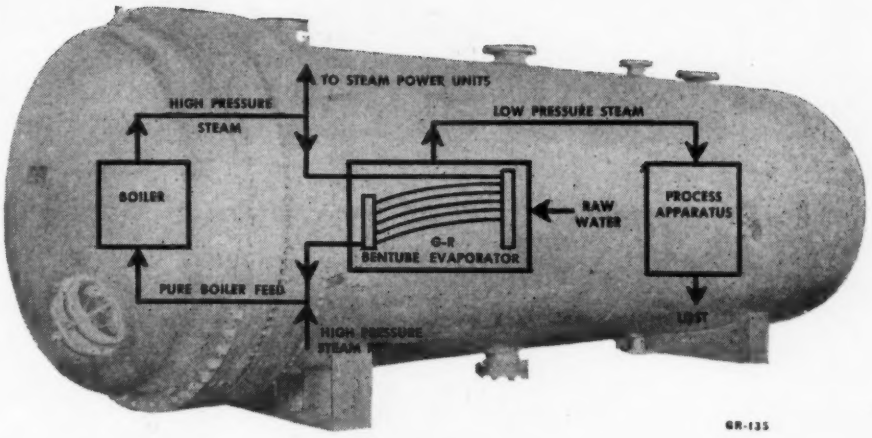
A new line of reciprocating compressors, ranging from 5 to 100 hp., and designed for low temperature duties, are being built so they can be assembled in as many as 1000 different combinations, making it possible to "tailor" each unit for the requirements of each installation, the manufacturer stated. The line is designed so that all components—compressor, motor, base, coupling, and condenser—can be individually selected for the job. Assembly does not require special tools, it was said. The Carrier Corp.

15—Package Steam Generators

Two series of packaged steam generators up to and including the 27,000 lbs./hr. range, are now available for use. Designs provide for both oil and gas-firing, in a low pressure (up to 250 psi.) and a high pressure (up to 850 psi.) series. Units are furnished completely assembled, including refractory and insulation. Basic design provides for installation of superheaters either as original equipment or for later addition. Combustion controls can be had for full or semi-automatic operation as desired. Foster-Wheeler Corp.



More "What's New!" Items, Page 174



Investigate This Efficient

THERMAL REDUCING VALVE

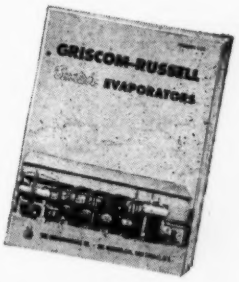
If You Use Process Steam

The above simplified flow chart shows how a G-R Bentube Evaporator can serve to produce large quantities of low-pressure steam for process work. The advantages:

THE G-R BENTUBE EVAPORATOR

1. The high-pressure steam used to operate the evaporator is all returned to the boiler, after use, in the form of condensate.
2. No raw, scale-forming make-up or contaminated condensed process steam is fed to the boiler, thus reducing boiler maintenance.
3. The scale-shedding heating elements of the G-R Bentube Evaporator maintain rated heat transfer without requiring hand scaling.
4. The evaporator is practically 100% thermally efficient.
5. Ideal plant heat balance can be arranged.

Many millions of pounds per hour of process steam are now being produced in highly successful G-R Bentube Reducing-Valve Evaporator plants. For more complete details, write for free copy of our Bulletin 364.

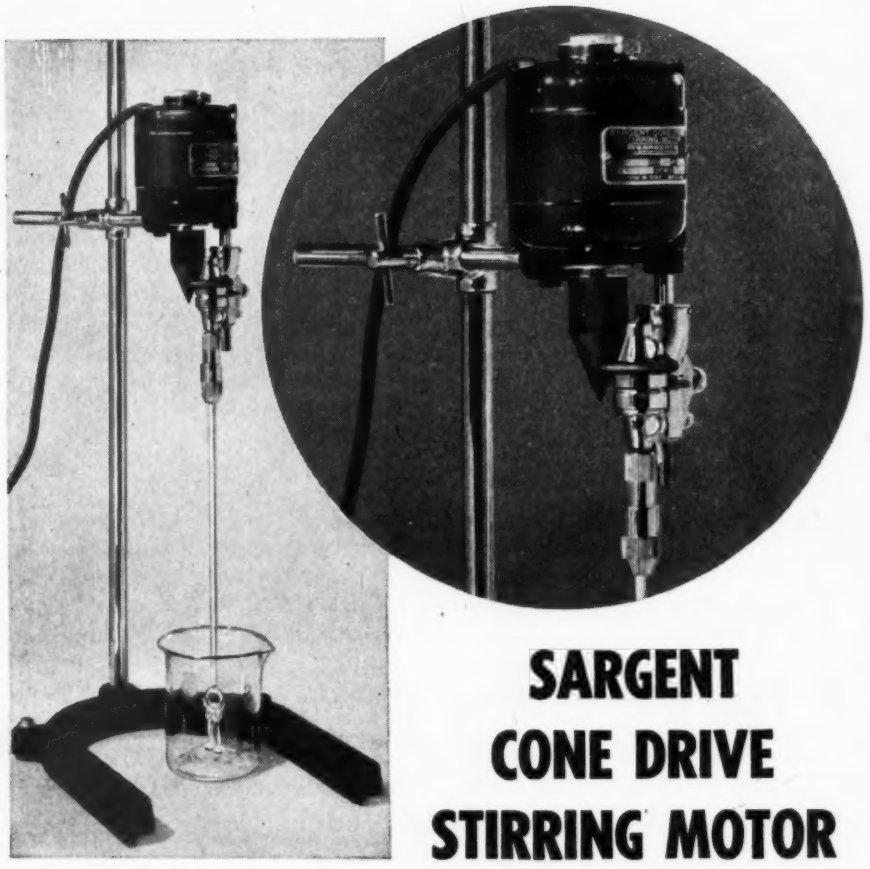


THE GRISCOM-RUSSELL CO.

285 Madison Ave. New York 17, N. Y.

GRISCOM-RUSSELL

Pioneers in Heat Transfer Apparatus



SARGENT CONE DRIVE STIRRING MOTOR

Smooth, Vibrationless Drive with full power of motor delivered at all speeds

Throughout the entire speed range of 75 to 1300 r.p.m., the Sargent Cone Drive delivers *full* motor power, is vibrationless and silent, and assures constancy of any selected speed. It is, therefore, as efficient for such applications as the rotation of electrodes and calorimeter paddles at speeds of about 200 r.p.m. or less, as it is for general stirring operations at higher speeds. Fine adjustment of speed is made by means of an adjusting nut which changes the effective diameter of the cone in contact with the friction ring. Because the motor is a brushless, induction type not containing centrifugal switches, it is relatively safe against explosion. The simple right angle clamp permits rapid adjustment of the motor to any desired position in horizontal and vertical planes.

S-76445 Sargent Cone Drive Stirring Motor. (Patent No. 1,973,576.) Complete with cross support rod, right angle clamp, connecting cord and plug, but without support stand. For operation from 115 volt A.C. 60 cycle circuits $33.50

S-76455 Ditto. But for 115 volt D.C. circuits $38.50

S-76465 Ditto. But for 230 volt A.C. 60 cycle circuits.....$34.50

S-76475 Ditto. But for 230 volt D.C. circuits $40.50

S-76480 Anode Chuck and Cathode Collet $1.50

S-79225 Support only for Sargent Cone Drive Stirring Motor (illustrated above). Designed with considerable mass to minimize support vibration. The heavy U shaped base accommodates vessels up to six inches in diameter and larger vessels can be placed on top of the base which has a flat surface. Supplied with a ⅝" rod, 30 inches long and adjusting screws to insure a solid four point support on any surface. Each.....$10.00

E. H. SARGENT & CO., 155-165 E. Superior St., Chicago 11, Ill.

Michigan Division: 1959 East Jefferson, Detroit 7, Michigan

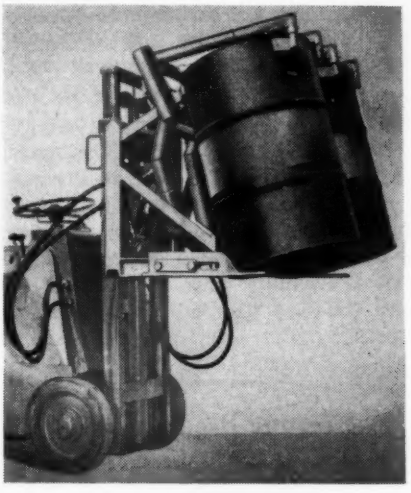
SARGENT

SCIENTIFIC LABORATORY SUPPLIES

What's New!

16—Drum Truck

The "Drum Master" can be installed on any hydraulically operated fork truck; is recommended for use in a truck of 2000 lbs. capacity. It handles two standard size drums with chime clamps similar in operation to hook device on conventional two-wheel barrel truck. Design enables quick accommodation for any size container, and will pick them up singly or in pairs. The Drum Master weighs 500 lbs. and is made of heavy gage stock with welded construction. William Ehlers.



Trade Literature

17—Generator Sets

Bulletins No. 1370 *and* 1371 describe a new line of gasoline electric generator sets in sizes from 10 to 125 KW, also furnished with natural gas and butane engines. The Buda Co.

18—Aromatic Compounds

Technical Bulletin C-7-104 covers physical and chemical properties, specifications, and other technical data on sec-butylbenzene (2-phenylbutane), now available in tank car lots, and suggested as a raw material for the preparation of aryl sulfonic acids and derived alkylated phenols, substituted nitrobenzenes and anilines, halogenated alkyl benzenes, and the unsaturated compounds produced by dehydrogenation. Koppers Co., Inc.

19—Laboratory Accidents

For Laboratory Safety, a 40-page, pocket-size, booklet of safety rules, illustrated with cartoons, for petroleum industry laboratory use. Standard Oil Co. of New Jersey.

More "What's New!" Items, Page 176

COOPER
CERTIFIED
STAINLESS STEEL
MONEL · NICKEL

VALVES and FITTINGS (SCREWED • FLANGED • WELDING)

COOPER ALLOY DESIGNATIONS		TYPICAL PHYSICAL PROPERTIES	
C 17	Cr. 18%, Ni. 8% C. Max. 20%	Tensile St. Yield Pt. Elong. 2 in. Red. Area Brinell Wt. per cu. in.	85,000 psi 45,000 psi 50% 50% 165 .28 lb.
C 17 S	C. .07—.10%		
C 17 SMO	C. .07—.10% Mo. 3% C. .07—.10% Cb. .70%—1%		
C 17 SCB			
C 22	Cr. 24—28% Ni. 9 —12% C. .20—.50%	Tensile St. Yield Pt. Elong. 2 in. Red. Area Brinell Wt. per cu. in.	90,000 psi 60,000 psi 30% 35% 180 .28 lb.
C 22 S	C. .10% max.		
C 25-20	Cr. 24—26% Ni. 19—20% C. .20—.30%	Tensile St. Yield Pt. Elong. 2 in. Red. Area Brinell Wt. per cu. in.	65,000 psi 45,000 psi 22% 25% 180 .29 lb.
C FA20	Cr. 19—21% Ni. 28—30% C. Max. .10% Molybdenum 3—4% Silicon 1.5% max. Cu. 4-4.5%	Tensile St. Yield Pt. Elong. 2 in. Red. Area Brinell Wt. per cu. in.	75,000 psi 45,000 psi 40% 45% 140 .29 lb.
MONEL (MM)	Ni. 67% Cu. 28% Fe. 3% Si. 1%	Tensile St. Yield Pt. Elong. 2 in. Red. Area Brinell Wt. per cu. in.	65,000 psi 33,000 psi 25% 28% 150 .32 lb.

COOPER ALLOY . . . largest exclusive producer of Stainless Steel, Monel and Nickel Castings for the Process Industries; including tube supports, valve trim, pump castings, heat exchanger castings and others.

Catalog available on request.

25 YEARS

THE COOPER ALLOY FOUNDRY CO.
HILLSIDE, NEW JERSEY

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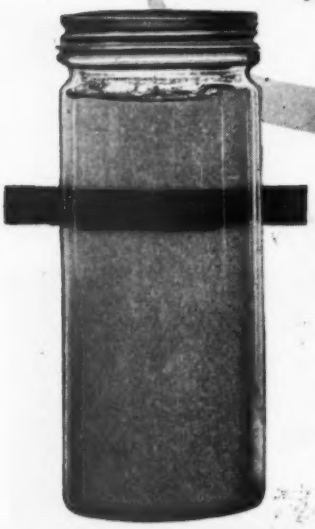
Quality seen at a glance

AND PROVED BY YEAR-ROUND PERFORMANCE!



See what the crystal-clear transparency of lubricants made with Metasap Stearate Bases means — *quality* assurance for your customer. Know that these water-insoluble, anhydrous lubricants will not dissolve when wet by rain or puddle splashes — will not separate, bleed, cake, freeze or evaporate—will perform efficiently under *all* temperature conditions.

And, compared with lime or soda base greases, Metasap Bases give your greases *less* base and *more* mineral oil — the true lubricating ingredient. Furthur, any desired consistency is obtainable—from a hard, stiff, short-feathered grease to a thin fluid lubricant.

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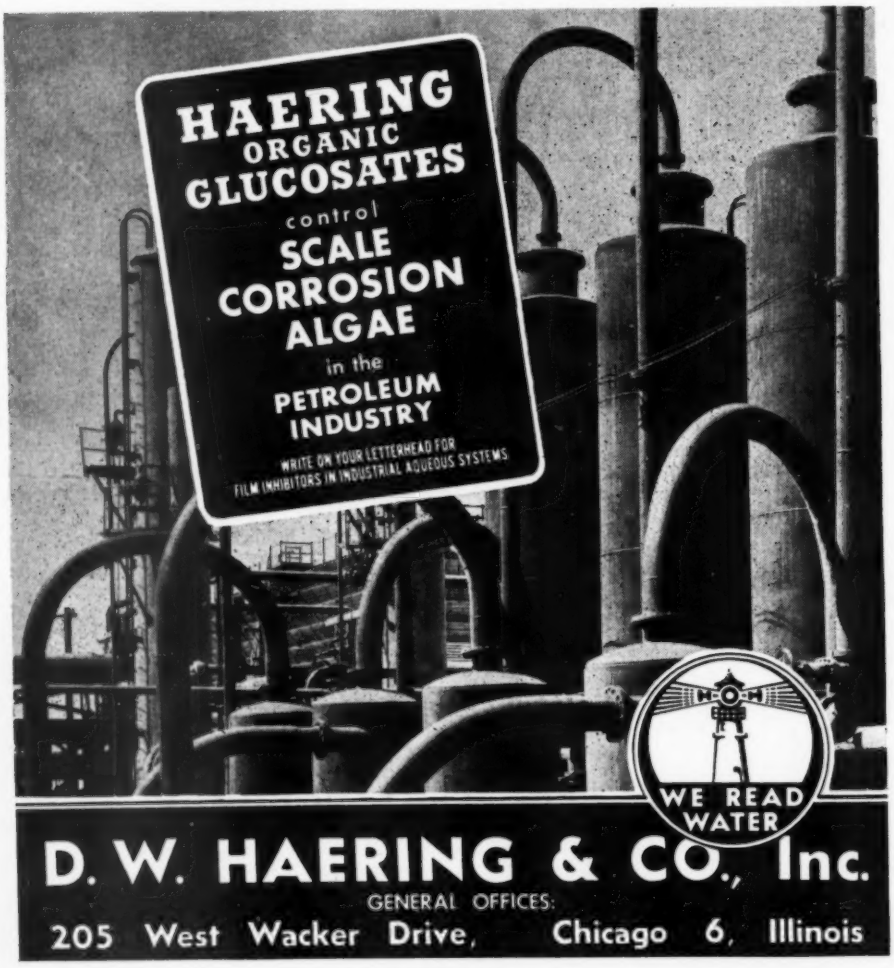

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What's New!

20—*High Pressure Pump*

BJ Hydroplex Pump, Bulletin 47-8020, describes a split case, multi-stage, centrifugal for efficient, low capacity, high-pressure pumping; equipped with direct-connected electric motor, it has a head range of 450 to 1700 ft., capacity of 10 to 140 gpm. Byron Jackson Co.

21—*Diffraction Instrument*

Electron Diffraction Instrument, Bulletin GEA-4905, covers uses and specifications of the device useful for example in studies of corrosion, catalysts, and lubricants through examination of surface or film characteristics. General Electric Co.

22—*Safety Valves*

Bulletin No. 50, provides condensed specifications and other pertinent engineering data on a line of safety and relief valves. Farris Engineering Corp.

23—*Steam Traps*

Selecting the Right Type Steam Trap, Bulletin No. 1600, features an easy-to-use copyrighted guide for the selection of steam traps for specific operations. Sarco Co., Inc.

24—*Stainless Weld Fittings*

Stainless Steel Welding Fittings and Flanges, Bulletin 476, covers dimensional data on a complete line of alloyed fittings; in pocket size for convenience in use. Taylor Forge & Pipe Works.

25—*Tube Cleaners*

Rotojet, a 4-page bulletin describing a new line of air or water jet-operated tube cleaners, and specifying the type cleaner recommended for each size and type of tube. Elliott Co., Roto Div.

26—*Tantalum*

The Metal Tantalum, 20 pages of data on a metal with wide application, including, physical, chemical, electrical, and corrosion properties, fabricating techniques, and available forms. Fansteel Metallurgical Corp.

27—*Vertical Centrifugal*

Triplex Pump, Data Sheet No. 66, presents construction and operation, approximate dimensions and comparative discharge flows for the Aldrich Inverted Vertical Triplex Pump, recommended for high pressure applications in the petroleum field. Aldrich Pump Co.

More "What's New!" Items, Page 178

Don't listen to Back-Fence Gossip

THERE'S PLENTY OF *Furfural* FOR ALL

We'll let you in on a secret. The recent announcement that furfural will soon be used in the manufacture of nylon was no surprise to us. And should this new use for furfural be followed by announcements of the adoption of furfural for other process industries you can be pretty sure that we will have had foreknowledge of those new requirements as well.

All of which means, that we have an ample supply of furfural for your needs. Present capacity of our two plants at Cedar Rapids, Iowa, and Memphis, Tennessee is upwards of 50,000,000 pounds per year. New techniques in manufacture indicate that even greater output can be obtained in present facilities and even these facilities are being continually expanded to meet anticipated demands.

So to you who are working with furfural experimentally now, we suggest that you intensify your development program without worry about availability. To you who have not yet investigated furfural's possibilities in your processes, may we suggest that the versatility of furfural as shown by its present uses, indicates there are still greater developments on the way. Perhaps you may be the one to make the headlines.

Quaker Oats Technical Staff will be glad to work with you on the application of furfural or the other furans to your particular problems.

Bulletin 203—Physical Data on Furfural contains information that will be of interest to you. Copies obtainable when requested on your company letterhead.

The Quaker Oats Company — CHEMICALS DEPT.

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In Australia, Swift & Company, Pty. Ltd., Sydney

FURFURAL • FURFURYL ALCOHOL (FA) • FUROIC ACID • TETRAHYDROFURFURYL ALCOHOL (THFA)

28—Water Columns & Gages

Water Columns and Gages, Bulletin WG-1811, 20-page bulletin describing Yarway boiler water level indicating equipment, including dimensions and prices. Yarnall-Waring Co.

29—High-pressure Valves

Edward, Catalog No. 12-G6, describes forged steel chrome-molybdenum Intex and Univalves; Univalves are welded bonnet integral seat valves for service at 1500 and 2500 psi. at 1000° F., Intex are bolted bonnet valves rated at 1500 psi., 1000° F. Edward Valves, Inc.

30—Temperature Control

Temperature Control in Oil Refinery Fabrication and Processing, an issue of *Tempil Topics* providing tips and techniques for improved control of temperature. Tempil Corp.

31—Regulators

Keckley, Catalog 48MC, gives dimensions, applications, capacities and other specifications on pressure and temperature regulators for steam and liquids, and data on self-cleaning strainers and steam traps. O. C. Keckley Co.

32—Rotameters

Rotameters, Catalog 18-R, a 36-page booklet covering Rotameters, specific gravity indicators and flow indicators, including tables for the selection of the correct instrument for a specific application. Schutte & Koerting Co.

33—Protective Coating

Lasting Protection for Metal Surfaces, a 12-page booklet presenting data on "Dum Dum for Metal" a new pliable, water-repellent coating for protection of metal surfaces from outdoor exposure. The Arco Co.

34—Centrifugal Pump

Mission Centrifugal Pump, an 8-page bulletin explaining the Scherzer hydraulic principle used in the design of the Mission centrifugal pump which provides streamlined flow from a concentric casing, and eliminates a major part of cavitation problems. Mission Mfg. Co.

35—Industrial Manostat

Automatic Vacuum and Pressure Control, Bulletin 1CM-96, gives technical details on the new Cartesian Manostat, Model No. 5 Industrial, a controller based on the principle of the Cartesian Diver. (See "What's New!" December, 1947, p. 961, Item 1). Emil Greiner Co.

36—Servo-mechanisms

Servos, a 16-page reprint of articles on the theory and function of servo-mechanisms for automatic control devices, which originally appeared in the June, July, and September issues of *Machine Design,* Askania Regulator Co.

Announcing to the Petroleum Industry

ATWOOD AND MORRILL CO.

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Manufacturers of Special Valves and Control Equipment
For Oil Refineries, Chemical Plants,
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- **TURBINE AND CONDENSER EQUIPMENT**
- **AIR AND HYDRAULICALLY OPERATED VALVES**
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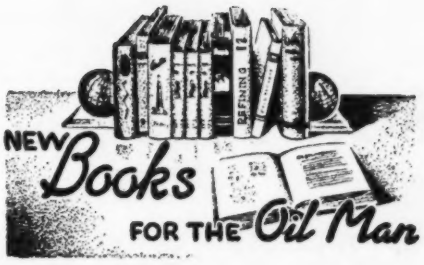
For Your Convenience

Business reply cards are included in this issue of PETROLEUM PROCESSING to assist you in obtaining more information on any items reviewed in "What's New!" You'll find them facing page 169. Just circle the numbers corresponding to the numbers on the items you're interested in, fill in the bottom of the card, and drop it in the mail. No postage required.



Copies of all books reviewed here may be ordered from the Reader's Service Department, Petroleum Processing, 1213 West Third St., Cleveland 13, for the prices listed, postpaid, unless indicated otherwise. Ohio purchasers please add 3% tax.

Technology Reviews Are Revived By British Petroleum Institute

Petroleum Technology, Vol. 7, edited by F. H. Garner, E. B. Evans, and George Sell, 6 x 9 in., 543 pages, stiff cloth binding, indexed.

Normally an annual review, the British Institute of Petroleum's *Petroleum Technology*, Vol. 7, is the first since Vol. 6 which was published in 1941 and covered the year 1940. The present volume is for the period 1941-45, and largely refers to the war years.

Because of the large amount of reference material and information on which the review is based—nearly 3500 original articles in published literature—the book has been limited somewhat in scope. Subjects which have been included are geology, geophysics, drilling, transportation in the United States, refinery process developments, analysis, chemistry and physics of petroleum, natural gas, LPG, and natural gasoline, benzole, synthetic fuels, diesel fuels, gas oils, lubricants, asphalt and road materials.

Topics omitted from this volume, but planned for the next which will relate to the year 1946, include: gasoline and other light distillates, furnace fuels, measurement, instrumentation, crude oils, waxes, insulating and hydraulic oils, engines and automotive equipment, British legislation, and statistics.

The book is well-indexed both by subject and by names, and includes a comprehensive bibliography of petroleum literature.

More Competition in Oil Needed New Study on Policies Argues

A National Policy for the Oil Industry, by Eugene V. Rostow, 6 x 9¼ in., 190 pages, stiff cloth binding, indexed, $2.50. (1948)

A National Policy for the Oil Industry should be read by every individual whose livelihood is earned through petroleum—whether he be a part of marketing, transportation, refining, or production; whether he be in research, engineering, administration, supervision, or sales.

The book is a scholarly study of the forces which determine petroleum prices and output. It examines the functioning of our law system which defines public policy toward the oil industry, and it considers alternative courses of action for the industry which might be pursued in the national interest.

The conclusions reached are 1) that the oil industry is monopolistic to an important extent, and 2) that a more competitive form of organization is economically and socially desirable and should be possible. It believes this reorganization could be achieved under the present Anti-Trust Laws, or under special petroleum legislation. It argues that such a reorganization in the interest of competition would not involve giving up the economies of large-scale production, but should on the contrary eliminate great wastes associated with excessive size and monopoly.

The five parts into which the book is divided cover studies and descriptions of the history, geography, technology, and law of the industry; existing controls on crude oil production; on product markets; the foreign oil situation; and a presentation of suggested methods for restoring free enterprise and full competition.

The present volume is the first in a series of Studies in National Policy with an editorial committee consisting of Percy E. Corbett, Kent T. Healy, Harold D. Lasswell, John P. Miller, and Eugene V. Rostow. The series will present the result of studies made in a program of research organized at Yale University in 1946, under the auspices of members of the Department of Economics and Political Science, and the School of Law.

Author Rostow is Professor of Law and a member of the Graduate Faculty of Economics at Yale.

Issue Revised Third Edition of UOP Test Methods for Petroleum

U. O. P. Laboratory Test Methods for Petroleum and Its Products, 3rd Edition, 6 x 9 in., 354 pages, illustrated, indexed, flexible binding, $14.00. (1947)

Growing demands for copies of *UOP Laboratory Methods* have resulted in this new revised third edition. The book is a compilation of about 80 methods for making tests on various petroleum products. None of these methods are included in the ASTM Standard Tests of the American Society for Testing Materials, but all have been tested and proved in the UOP Laboratories to be operable and dependable.

The manual is intended to give methods specifically useful for the small refinery laboratory, and is supplementary to the ASTM procedures. It is divided conveniently into 11 sections, each separated by a heavy paper introductory page containing the index of that section.

Subjects covered include general analytical procedures, asphalt and road materials, coal, crude oil, fuel oil, gas, gasoline, kerosene and diesel fuel, lubricating oils, solvents, and catalysts.

The book can be obtained direct from Universal Oil Products Co., 310 So. Michigan Ave., Chicago 4, Ill.

Offer Deterioration Abstracts On Annual Subscription Basis

Prevention of Deterioration Abstracts is now being offered on a yearly subscription basis by the National Research Council of the National Academy of Sciences.

The Abstracts are set up under the following headings: biological agents; electrical and electronic equipment; fungicides and other toxic compounds; lacquers, paints and varnishes; lubricants; metals, leather; optical instruments and photographic equipment; plastics, resins, rubbers, and waxes; packaging and storage; textiles and cordage; wood and paper.

Items abstracted include journal articles, patents, specifications, unpublished reports prepared by various Army, Navy, and other governmental groups, and unpublished British, Australian, and Canadian reports.

There will be approximately 1500 pages of the Abstracts per year. The individual abstracts are in looseleaf form, so that they may be arranged in the manner desired by the individuals receiving them. During the calendar year, all the abstracts classified under any one heading will be numbered consecutively.

The price, which includes two binders and index guides, will be $37.50 per year. Two binders are required for one year's subscription. The fiscal year will be from July 1 to June 30. The Abstracts series started April, 1946, and back issues may be obtained at the regular subscription price.

Orders should be sent to the Prevention of Deterioration Center, National Research Council, Room 204, 2101 Constitution Avenue, Washington 25, D. C.

ASTM pH Symposium Includes Petroleum Products

Symposium on pH Measurement, 6 x 9 in., 86 pages, heavy paper cover, illustrated, $1.50.

Methods of making pH determinations in the field of petroleum products are explained in a paper by L. Lykken of Shell Development Co. which is included in the recently pub-

NEW BOOK—NOW READY for immediate delivery . . .

"INDUSTRIAL WASTE DISPOSAL

for

Petroleum Refineries and Allied Plants"

Disposing of industrial wastes is a never-ending problem—yet there has been a surprising lack of up-to-date information and authoritative reference data on this important subject.

For that reason, "INDUSTRIAL WASTE DISPOSAL" is a book that fills a real need and will be welcomed by all engineers and technicians who are concerned with effective, economical control and disposal of harmful wastes.

The author—W. B. Hart—is a widely recognized and highly respected authority in this field, having been actively engaged in solving the problems of industrial waste disposal for the past 20 years. Mr. Hart is a graduate of the University of Pennsylvania with the degree of Doctor of Pharmacy. With Atlantic Refining Company since 1923, he has charge of waste disposal for his Company, and is Chairman of the Committee on Disposal of Refinery Wastes of the American Petroleum Institute.

"INDUSTRIAL WASTE DISPOSAL" is a complete treatise, starting with a brief review of the economic and legislative backgrounds; then a full discussion of the kinds of industrial wastes and their harmful effects; and right on through the "how" of proper waste disposal.

There is a wealth of reference information and operating facts in this book; over 100 pages (8½ x 11) of material, presented clearly and logically under these main divisions . . . .

ECONOMIC and LEGISLATIVE ASPECTS

KINDS OF WASTES

EFFECTS OF INDUSTRIAL WASTES

PRELIMINARY INVESTIGATIONS

TREATMENT OF OIL-CONTAINING WASTES

The text of "INDUSTRIAL WASTE DISPOSAL" was first published as a series of articles in Petroleum Processing magazine, intended primarily for refinery engineers; however, a large part of the material is so basic that it is applicable to all kinds of waste control—whether in a refinery, a dairy, a tannery or other type of industrial plant.

Methods for determining, measuring and controlling industrial wastes are covered in a thorough and wholly practical way, with appropriate sketches and diagrams.

For the man who works directly on industrial waste control, this new book is a valuable 'on-the-desk' ready reference; and it is a useful addition to the general library of all plants having a waste control problem. Finding quick answers to specific problems is facilitated by a detailed index; and the bibliography of 174 references is a real help when it is necessary to dig fully into the details of a particular phase of the general waste disposal problem.

"INDUSTRIAL WASTE DISPOSAL" is the most complete and up-to-date book on this important subject . . . 68 detailed illustrations, 11 tables, 103 pages, 8½ x 11, attractively bound in stiff cloth covers, with the title stamped in gold on front cover and backbone . . . a convenient, practical desk reference and a valuable addition to any technical reference library, private or public . . . . $4.00. *Ohio purchasers, please add 3% sales tax.*

PETROLEUM PROCESSING

1213 West Third Street Cleveland 13, Ohio

lished *Symposium on pH Measurement.*

The seven papers and discussion comprising the Symposium are intended to present the latest theory and practice on colorimetric and potentiometric methods for making pH and closely related measurements. They were presented at the 49th Annual Meeting of the American Society for Testing Materials in Buffalo, 1946.

The symposium was organized and sponsored by Technical Committee XIII on Hydrogen Ion Determinations. Four broad topics are covered: a history of the field; a discussion of fundamentals and the broad theoretical basis for pH determinations; recent advances in the principal methods and techniques; and applications to particular fields, as covered by Mr. Lykken's study.

Because the customary methods of determination of pH are in aqueous solutions, workers in the organic field have resorted to the use of dilution by solvents, according to Mr. Lykken. The low dielectric constants of most organic liquids prevent satisfactory measurements of the hydrogen ion directly. However, it is shown to be often possible, with adequate empirical standardization, to utilize the technique of dilution of the sample in a more polar medium followed by potentiometric measurement of pH in the solution.

Technical Meetings For Oil Men

February

15-19, American Institute of Chemical Engineers, regional meeting, Roosevelt Hotel, New Orleans, La.
15-19, American Institute of Mining and Metallurgical Engineers, annual meeting, Pennsylvania Hotel, New York City.

March

1-8, American Society for Testing Materials, spring meeting, Statler Hotel, Washington, D. C.
9-10, Commercial Chemical Development Assn., Roosevelt Hotel, New York City.
24-26, Natural Gasoline Assn. of America, annual meeting, Texas Hotel, Ft. Worth, Texas.

April

5-7, Western Petroleum Refiners Assn., annual meeting, Galvez and Buccaneer Hotels, Galveston, Texas.
5-8, National Assn. of Corrosion Engineers, fourth annual conference and exhibition, Jefferson Hotel, St. Louis, Mo.
19-21, American Society of Lubrication Engineers, annual convention, Statler Hotel, Buffalo, N. Y.
19-23, American Chemical Society, 113th annual meeting, Chicago.
21-23, National Petroleum Assn., Hotel Cleveland, Cleveland.
28-30, Liquefied Petroleum Gas Assn., annual convention and trade show, Hotel President, Municipal Auditorium, Kansas City, Mo.

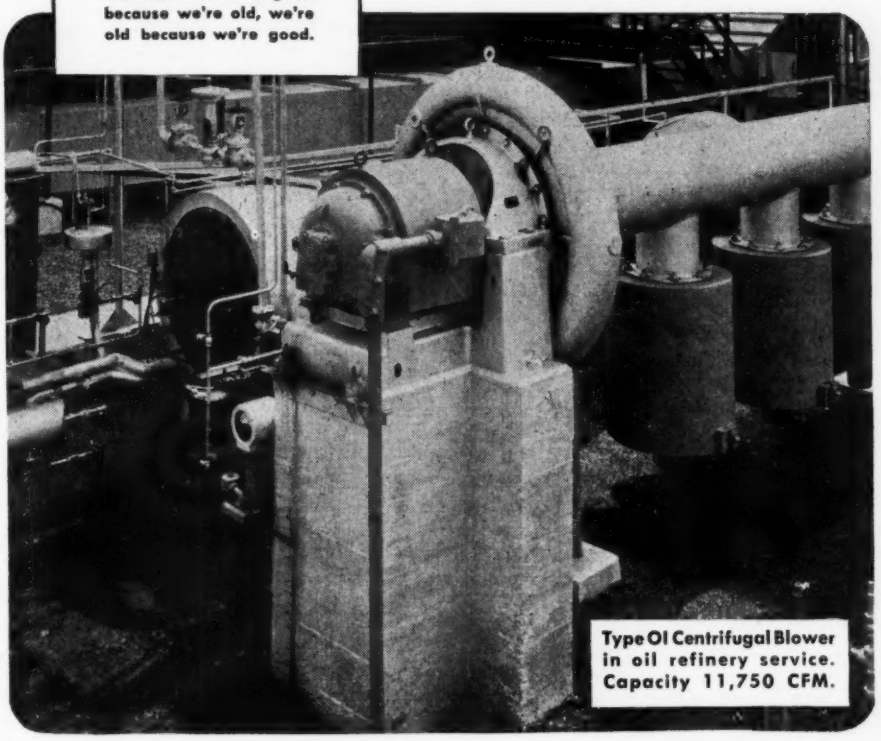
May

9-12, American Institute of Chemical Engineers, regional meeting, Hollenden Hotel, Cleveland.
10-13, American Petroleum Institute, Division of Refining, mid-year meeting, Ben Franklin Hotel, Philadelphia.
15-22, International Petroleum Exposition, Tulsa.

Oil was first produced by drilling in 1859, five years after the first Roots Blower was built. We're not good because we're old, we're old because we're good.

The ANSWER to GAS-MOVING jobs . . .

R-C dual-ability



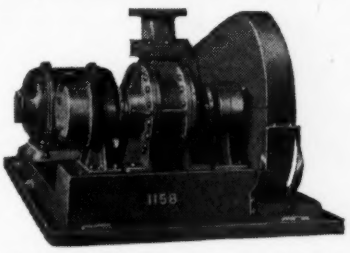
Type OI Centrifugal Blower in oil refinery service. Capacity 11,750 CFM.

For various petroleum refining and processing operations, Roots-Connersville Blowers, Exhausters and Gas Pumps are available in sizes and types exactly matched to the job to be done.

That's because of our *dual-ability* to recommend, without bias, and to supply either Centrifugal or Rotary Positive units, whichever best meets the specific needs. We are the only blower builders offering this *dual choice.*

Our smaller size Cycloidal Rotary units have proved especially successful for slack wax pumps and similar work. R-C Meters measure gas input or output with "cash register" accuracy.

Tell us your specific problems . . . and R-C *dual-ability* will help you find practical answers.



R-C Cycloidal Rotary Pumps can handle gas or vapor along with liquids, without loss of efficiency. They can be relied upon for long-time, economical operation.

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BLOWER BUILDERS R-C SINCE 1854
BLOWERS · EXHAUSTERS · BOOSTERS · LIQUID AND VACUUM PUMPS · METERS · INERT GAS GENERATORS

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PERSONALS

Petroleum Technologists in the Headlines

Dr. Arthur B. Hersberger, recently appointed manager of the newly organized chemical products division of The Atlantic Refining Co., has served with Atlantic's research and development department since 1936.

Dr. Hersberger

Dr. Hersberger graduated from University of Maryland in 1932, and four years later received his degree as Doctor of Philosophy in Chemistry from that institution. He then entered the employ of Atlantic as an assistant chemist, and has received various promotions since that time.

* * *

Barney Schwalm, Union Oil Co. of California, was recently elected to the board of governors of a newly-formed chapter of the Society of Automotive Engineers, Honolulu. He will also serve as editor and chairman of the SAE publications committee, Hawaii section.

* * *

Dr. Frank J. Soday has been appointed Director of Research of Lion Oil Co. and will conduct an expanded research program in the field of petroleum chemicals. He holds M.S. and Ph. D. degrees from Ohio State University. During the war Dr. Soday was Technical Director for the Copolymer Corp., Baton Rouge, and has recently been head of research work for Devoe and Raynolds Co., Louisville, Ky.

* * *

Frank M. Perry, Cities Service Oil Co., Bartlesville, is chairman of the convention program committee for the 27th annual meeting of the Natural Gasoline Assn. of America, which will be held March 24-26 at the Texas Hotel at Fort Worth.

* * *

W. H. Bahlke and **D. P. Barnard,** who as associate directors of research with Standard Oil Co. of Indiana have been engaged in liaison activities with other company departments and with other organizations, have been named to positions recently established, that of research co-ordinators. Dr. Barnard will carry on with his activities in connection with product quality, and with technical developments in the automotive and aviation fields. Dr. Bahlke will coordinate the development work of the company in the expanding petrochemicals area.

David P. Hankins of East Bank, W. Va. is the new superintendent at the Cabin Creek refinery of Pure Oil Co. He was appointed by **J. Porter Langfitt** vice president in charge of refining. **C. W. Cooper,** Cabin Creek superintendent since June 1945 goes to the Chicago office of the company where he will handle special assignments in the refining division. Mr. Hankins has been with the company for 23 years and at Cabin Creek for 12 years.

Harold P. Sanders, with Pure Oil since 1929, is the new assistant superintendent at Cabin Creek.

* * *

E. A. Evans, chief chemist to the Wakefield Group of Companies of England, has been nominated as president designate of the Institute of Petroleum of England, for 1948-1949. He has been with Wakefield since 1915, and is well known in the field of lubrication. Mr. Evans has also been chairman of Motor Industry Research Assn., since its inception in March, 1946. He was chairman of its predecessor, the Automobile Research Committee, during 1944 and 1945, and chairman of its Research Subcommittee from 1941 to 1943.

* * *

J. Dean Bradley, now manager of the operating division of the manufacturing department of Imperial at Toronto, is succeeded as general superintendent of Sarnia refinery by **Dr. J. L. Huggett.** Mr. Bradley has been in charge at Sarnia since 1944; Dr. Huggett came to Imperial in 1914.

* * *

Charles B. Dale, New York City, now a chemical engineer on the staff of the Pennsylvania Crude Oil Assn. at Bradford, Penna., has been on the staff of Foster Wheeler Corp.; was formerly a research engineer with Shell Development Co., Wilmington, Calif.

* * *

New department of exploration of Sunray Oil Corp., San Antonio, Tex., is now in charge of **Don O. Chapell,** vice president. Mr. Chapell's appointment to this position is the initial movement in a new development program. He will set up his office in Tulsa. **H. S. McClintock,** vice president, will continue to direct the land department of the company.

* * *

L. G. Smith is a new member of the board of directors of Creole Petroleum Corp. Mr. Smith is vice president in charge of refining activities. Resignations from the board of **W. J. Haley** and **W. R. Goodwin** have been announced.

Michael J. Rzasa, who recently received a Ph.D. in chemical engineer-from the University of Michigan, is now with the research staff of Stanolind Oil and Gas Co., Tulsa.

* * *

P. O. Howard has joined Warren Petroleum Corp. as natural gas engineer, to assist **J. T. Oxley,** manager of the gas division. A graduate of the University of Oklahoma in 1928 with a B.S. in geology, Mr. Howard has been for 13 years petroleum engineer and deputy oil and gas conservation officer for the Oil and Gas Conservation Dept. of the Oklahoma Corporation Commission. He is a past president of the Oklahoma Geological Society.

* * *

E. D. Cumming, formerly manager of Shell Oil Co.'s American department in London, is regional vice president of Shell for the Texas-Gulf and Mid-Continent areas. A graduate in engineering of Auburn, Ala., University, he was first employed by Shell on the Pacific Coast, and served as both technical assistant and manager of Shell refineries at Wilmington and Martinez, Cal.

In 1938 he became manager of Shell's Wood River refinery and in 1939 vice president in charge of manufacturing. During the war he was for a period PAW Director of Refining. He was made vice president in charge of exploration and production for the Pacific Coast area in 1944 and late in 1946 went into Shell service overseas.

* * *

Edwin C. Paige has been appointed head of the fleet section of the technical service division of Ethyl Corp. He succeeds **Errol J. Gay,** who has resigned to open a Detroit office as private consultant to automotive and petroleum companies.

Mr. Paige

Mr. Paige joined Ethyl in 1930, two years after his graduation from the University of Maryland with a civil engineering degree. He was first a field representative and then fleet engineer in the Ethyl office in Baltimore. In 1935 he was transferred to the former New York division with headquarters in Elizabeth, N. J. In 1940 he was assigned to the fleet section of technical service at Detroit.

Personals

Dr. J. Bennett Hill and **Dr. John M. Pearson** have been made directors of new divisions in the recently-created Research and Development Department of Sun Oil Co. A third division also has been added to the Research and Development Department by the transfer of the Patent Division from the Manufacturing Department. **Robert O. Spurdle** will continue as head of the Patent Division.

Dr. Hill

Dr. Pearson

Under the new setup, Dr. Hill, former manager of the development division of the Manufacturing Department, will head a new Chemical and Engineering Division, in which the chemical research and development and automotive engineering research for the entire company will be cntralized. In this division, **Stewart S. Kurtz Jr.,** will be manager of the chemical research laboratory, **W. Herman Barcus** will manage the development laboratory and **A. Ludlow Clayden** will manage the automotive laboratory.

Dr. Pearson, former director of physical research and development of Sun Oil Co.'s Production Department, will direct a newly-organized Physical Division. Laboratory manager of the Physical Division will be **Ford L. Johnson.**

J. Harold Perrine, formerly of the development division of the Manufacturing Department, is administrative assistant in the work of these new divisions of the Research and Development Department.

* * *

J. J. Mikita, former associate director of research for The Texas Co., will be directly in charge of the fuel testing laboratories being established by the Du Pont company. All laboratories will be under the administration of **J. R. Sabina,** technical director of the Petroleum Chemicals Division.

Laboratory managers named so far are: **Iver T. Rosenlund,** Road-Test laboratory, and **Kenneth C. Edson,** district laboratory at El Monte, Cal.; **Dr. Austin B. Wilder,** Chicago, and **Donald W. Frison,** Tulsa. Two new general laboratories are being established, the Road-Test laboratory at El Monte, and an Engineering laboratory at Deepwater Point, N. J. District laboratories will be divided into knock testing and gasoline inspection sections.

* * *

Dr. W. E. Hanford has been appointed to the newly created post of Director of Petroleum and Chemical Research of M. W. Kellogg Co. He will be in charge of all the company's laboratory work both at Jersey City and as expanded by University fellowships. Dr. Hanford joined the Kellogg organization in 1946, going to that company from General Aniline & Film Corp., where he was director of research. Earlier he spent 7 years with Du Pont, first as research chemist and later in a supervisory capacity.

* * *

J. W. Holmes is sales manager of Jefferson Chemical Co., Inc., owned jointly by The Texas Co. and American Cyanamid Co. A graduate of McGill University, Mr. Holmes for several years handled technical sales of organic chemicals and neoprene for Canadian Industries Ltd. in Montreal and Toronto. In 1942 he joined the Polymer Corp. at Sarnia, Ontario, as executive assistant to the managing director and later was placed in charge of technical service for butyl rubber. In 1945 he became manager of the Polymer Corp.'s sales and technical service division. He is a former chairman of the Ontario Rubber Section of the Chemical Institute of Canada.

Mr. Holmes

* * *

Afton D. Puckett is in charge of operations of all anti-knock equipment in connection with Du Pont's marketing of tetraethyl lead compounds and will be stationed at the Engineering laboratory at Deepwater Point, N. J. A native Texan he graduated in chemical engineering from Oklahoma A. & M. College in 1936 and has been associated successively with Tide Water Associated Oil Co., the National Bureau of Standards and the Bureau of Mines Petroleum Experiment Station.

Mr. Puckett

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EDITORIAL COMMENTS

WIDENING HORIZONS

Efficient Motor Fuel Utilization Assumes Economic Importance

TECHNOLOGISTS of the petroleum and automotive industries, in the recent annual meeting of the Society of Automotive Engineers in Detroit, discussed their problems from a new economic platform, brought about by the narrowing relationship between supply and demand for motor fuels and other petroleum products. For the first time in the cooperative work of the two industries, consideration of fuel economy in car operation is of paramount importance. Inventive thinking of automotive engineers directed along this line in a few years may bring important changes in motor fuels as well as the cars that use them.

In the past engineers from both the oil companies and the car manufacturers have discussed from the SAE and other forums problems experienced in vapor lock, engine knock and other operating conditions in relation to fuel oil systems and engine design. Up to the present time, these discussions have been in the abstract. Motor fuel supplies were considered ample, except for the wartime emergency, and their prices were relatively lower than for most commodities.

Under such conditions there was no urgency for the manufacturers to continue to design their new models for anything but top performance, to please the customer's vanity. When the new cars were built, the increased compression ratio and other advanced engineering features were used to secure improved performance at the most severe driving conditions, rather than for general better fuel utilization resulting in fuel economy at normal driving conditions.

The petroleum economics picture has now changed, however. Car owners feel it in the higher prices they pay for their gasoline fills. They are likely to be more expressive on this subject than in the past. The car manufacturers' sales departments probably will be more susceptible to their engineers' suggestions to direct design towards securing better fuel and oil utilization. Even so, it will be some five years before more efficient engines in new model cars could influence the volume of motor fuel consumption to any extent at all.

For the past year or so oil company representatives have been more emphatic in pointing out that greater attention to design of fuel distribution systems could provide for the use of more volatile motor fuels without the occurrence of vapor lock. With each year's new models, however, there was at least one instance where this engineering feature was neglected, and thus unnecessarily narrow vapor pressure limits for motor fuels have to be maintained. Raising the present vapor pressure limitation would provide for the greater use of butanes and natural gasoline in motor fuels by refiners, thereby increasing the total available motor fuel supply.

The case for better utilization of the octanes in present motor gasolines was presented before the SAE in a paper by W. M. Holaday, Director of Socony-Vacuum laboratories. The same paper also gave comprehensive data to show the cost to refiners of manufacturing gasoline of higher octane than the present levels. It was pointed out that higher prices to motorists for such motor fuels would of necessity result and that, to compensate for them, fuel economy must be achieved in the engines designed to use the higher octane fuels. On the other hand, it was stated that fuels of even lower than present octane ratings would give knock-free performance for up to 95% of average driving time. Discussion at the SAE meeting indicated automotive engineers are aware of the need for designing higher compression engines to secure operating economies, rather than to improve performance at peak engine operating conditions.

The petroleum and automotive industries in the past have enjoyed a high degree of co-operation in working out technical problems having to do with the fuel and lubricant requirements of automobiles. Such cooperation now directed toward securing improved utilization of the over 2,000,000 barrels of motor gasoline consumed daily in the nation's cars, can make an important contribution to the conservation of this resource.

Laboratories Now Are As Modern As Plant Processing Equipment

(An old time "tester" pays his tribute to the facilities for scientific work the oil companies are today installing.)

THE trend in modern laboratory construction parallels the heightened importance with which research and scientific methods today are regarded by industry. The newest of its type, Shell Oil Co.'s $1,300,000 Production and Exploration Research Center in Houston, is an outstanding example in the design of this type of facility. Emphasis has not only been placed on functional efficiency, also keeping in mind future needs, but it represents about the last word in providing comfort and safety for workers. All glass in the windows and doors is shatterproof. A company-operated cafeteria with a covered terrace has been installed.

Eye appeal is taken care of by terazzo and asphalt block floors, glazed tile walls in pastel colors, acoustically treated ceilings, minimum 50-ft.-candles of fluorescent lighting at work level, comfortable chairs, beautifully-appointed library—the list could go on and on.

Old heads among the scientific fraternity in the oil industry will well remember when they were expected to work in a tin shack with maybe a dirt floor, using whatever happened to be available in the way of rough lumber, packing boxes and the like to support the meagre equipment they were able to pry out of their respective managements. They didn't know what a 40-hour week was, automatic pay increases, hospitalization insurance, anuity benefits nor social security. Researchers in those days, now happily past, would not have had the temerity to even dream of a $1,300,000 laboratory such as Shell has built. Their company's annual research bill, including salaries and equipment and operating fund, just wasn't on speaking terms with a Million Dollars.

Shell and other oil companies are to be commended for the investments they are making in new laboratories and the facilities to operate them. Their chemists, physicists and engineers are even more deserving of credit. For they and their predecessors convinced company management that modern, adequate facilities for testing and research work are as important to continuing profits as the tanks, towers, stills and so on that turn out the products.—D.P.T.

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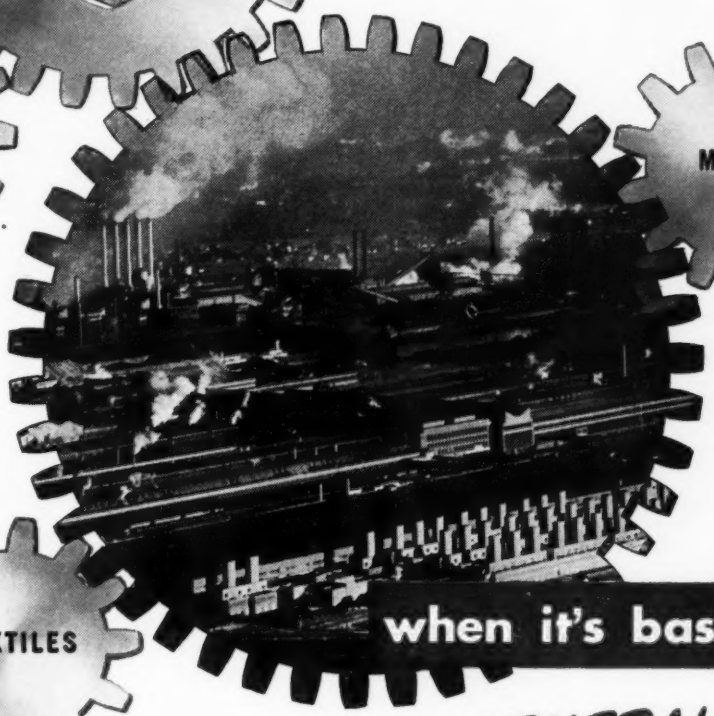

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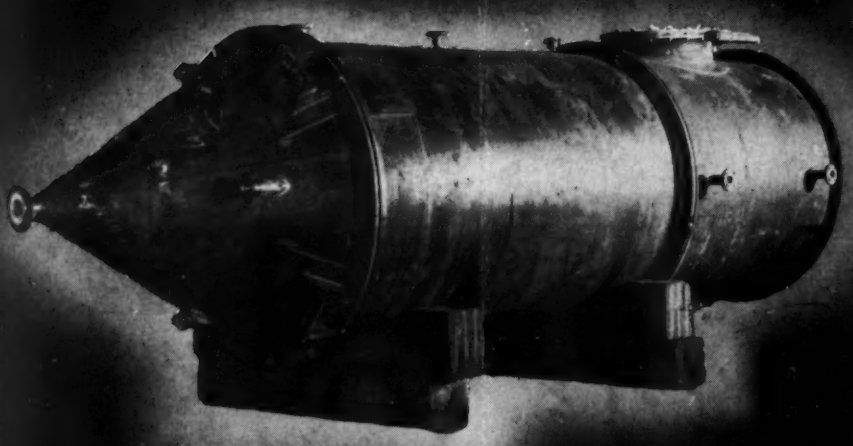

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